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A River-bottom Field of the Tennessee Experiment Station *Frontispiece*

Nature Studies on the Farm

SOILS AND PLANTS

BY

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NATURE STUDIES ON THE FARM.

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NATURE STUDIES ON THE FARM

I. INTRODUCTION

No boy or girl who has always lived in the country will need to be introduced to plants, as though they were strangers; but I want you not only to be acquainted with corn and cotton, with fruits and flowers, but also to know the way in which they grow, as well as something of the soil from which they get their food, of the roots that secure it, the leaves that digest it, and the fruit where the food is so largely used.

And I particularly want you to learn these lessons about plants very largely from the plants themselves. Therefore this book is to be read and not studied, as would be the case were it a geography or a spelling book. I can tell you in the book a few things that it is well to know, but the plant can tell you a great many more things that are both interesting and useful. I believe that the potato plant can tell boys things that will almost make them enjoy hoeing potatoes!

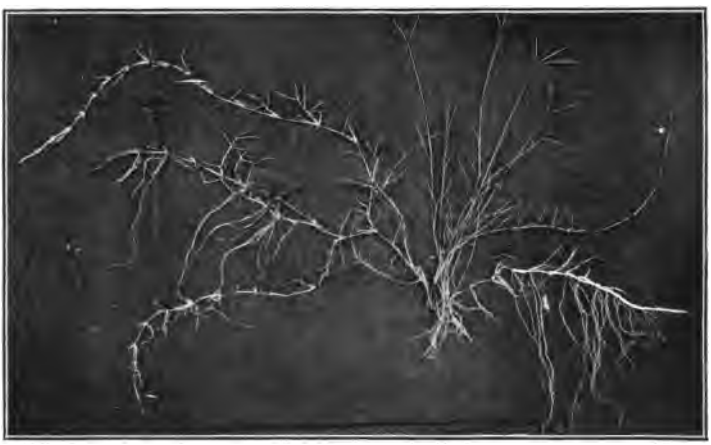
This work that we are to begin together is not plant study merely, but a study of the growing plant; and our purpose is to learn to help the plants to grow better, so that they may give us larger crops. To do this we must learn something about soils as well as about plants. We shall find that the same law of life applies to plants as to animals and to man. Like us, the plant grows best when it is fed best.

Strawberry plant.

Like us too, the plant is helpless when very young, and becomes stronger and better able to take care of itself as it grows older. Indeed, fruit trees are so much like people that the German gardeners call the place where young trees are grown a "tree-school," and all the fruit trees have to spend a few years there, learning how to grow.

And here is a question that I want to ask you: What are the differences between plants and animals? You say in reply, "Animals move from place to place, and plants do not." Are you sure plants do not move? Before you decide, please learn all

you can from the strawberry plant. Then see if the Bermuda grass stays in the spot where it is planted. Maybe there is a good place for wild ferns near your school. Find some "walking" ferns and see whether they are not spreading out to new places.



Bermuda grass.

Are you *quite* sure plants do not move? True, they do not run like colts, but neither do snails run, and in the nature books you will find stories of the coral which never moves, and of the oyster, which spends almost all its life in one spot. There are a great many plants that move easily. The green plant called pond scum moves readily through water, and a host of other plants do the same; and then there

are all the little plants, so small that we cannot see them, which float about in the air like dust.

You may say, "Animals eat food, and plants do not." Let us see about that. We know that plants

Walking fern.

grow; because we see them get larger from week to week and from year to year; but they cannot grow without food. You may say that they cannot eat without mouths; but every plant has a great many mouths covering all its young roots and much of its leaf surface, and these mouths are no more curious than those of many animals. The plant must have its food just as surely as a cow or a horse.

Plants breathe in a way of their own, and, indeed, they do almost everything that animals do. They do not hear or talk, but you know there are even people who are deaf and dumb; and plants have their own way of making their wants known. Do you know how a plant tells that it is thirsty? When we have gone a little farther, perhaps we can see how a plant says that it is hungry.

Thirsty corn plants.

I have seen plants starve to death, and I have seen whole fields of wheat so nearly starved that the poor plants only grew half as high as well-fed wheat plants grow, and many of their stalks were headless. Every plant in the field did its very best to make well-filled heads, but they were too weak and starved; so instead of a big crop the farmer hardly got five bushels of grain

to the acre. I wonder whether that farmer starved his boys and girls as he did his wheat. Like all other good plants the wheat plant gets its food from the soil. The dodder and the mistletoe steal their food from the plants on which they grow, but they are thieves.

As plants depend on the soil for their food, we may well begin our study where the plants begin to grow.

II. ORIGIN OF SOILS

ALL of the land is called soil, down to the hard rock which lies at a greater or less depth below the surface. In some places the soil is very deep; in others it is only a few inches in depth; while there are small spots on the earth's surface where there is no soil, but only bare rock. When we speak of soil we usually have in mind only the surface layer, which is darker-colored, more fertile, and more porous than the subsoil. But the deep-lying clays are soil, and the pure sands that are found along rivers and often in layers under the surface are soils also, and have a great influence on the fertility of the land.

Now, if this were a fairy story, I should begin with "Once upon a time," and then tell you how, a great many years ago, the whole earth was covered with water, and in some way a little strip of soft rock was raised here and there above the sea. And the waves washed the rock, just as you may see the waves of a river wash the shore, and little bits of rock and shells were broken loose by the waves and carried by sea currents to other places, where they settled, making big sand bars, that at last reached the top of the water — just as sand bars are formed along our creeks and rivers. And as the land was raised higher the frosts cracked the rocks, and the lightning broke

them, and the rains beat upon them, forming streams and rivers that washed the loose parts down to lower places, grinding the broken stone and mixing it all up. When plants grew on the earth they too were

Sand bar in creek.

swept down by the water and mixed with the broken stone, which became finer and finer until some of it was like dust.

In this fine earth, made of ground rock mixed with leaves and twigs, worms and other small animals lived, making burrows and still farther mixing the earth which the water had ground. Finally all this grinding and mixing and moving from one place to

another made the rock into soil. Soil-making has been going on since the world began, and soils are being made to-day just as they were when the world was young.

When it rains again see if you can find any roadside stream that is not muddy. Why is not the water in it clear? Make a strong dam across such a stream, and when the rain has ceased see what you can find in your dam. Then go down to the creek and see if the rain has made any changes along the creek banks. Has it washed away soil in one place and made a little bar in another? Well, that is soil movement and soil-making.

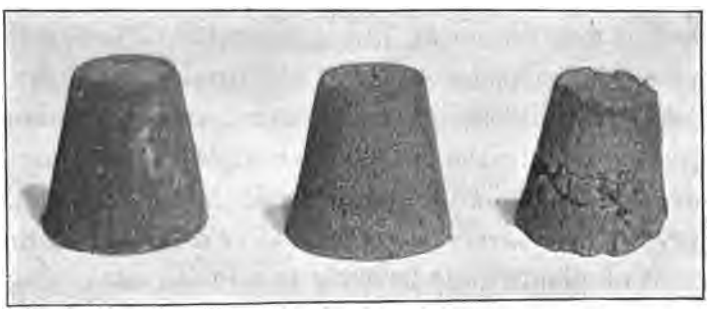
The next time you dig worms to fish with, please search very carefully for the holes the worms have made in the soil, and you will be surprised to see how many there are, and how they go in all directions. Then remember how the roots of the trees pass through the soil. Every worm hole, and every dead root, is a place for water to get through, carrying tiny bits of surface soil to the subsoil and thus changing it.

So we see that the soil is changing all the time, and I suppose there are almost as many living things in the ground as there are above ground, all working on the soil, mixing and moving, and thus making it over and over again.

III. KINDS OF SOIL

THERE are three kinds of soil: clay, sand, and loam. Clay is very fine soil, with more or less lime and decayed plants and animals mixed with it. Pure clay is so fine that when moist it can be molded into many shapes, and when dry and burned these will hold water. This is the way our dishes are made. Most clay soils are impure, and do not hold water like pure clay. All clay soils hold water much better than sand, because the clay is much finer and its parts stick closer together. Fine sand holds water much better than coarse sand or gravel. Water passes readily through sandy soil, and slowly through clay soil. If you will make a heap of stones, each as large as your fist, and another heap of small stones, a third of coarse sand, a fourth of fine sand, and a fifth of clay, and then pour water on all of them until they are wet through, you will see that clay holds water best. The big stones will be perfectly dry long before the clay is dry. This is because the clay is made up of very tiny bits, which are soft and cling together so that the water cannot get away from them, while there are big holes between the big stones through which all the water soon runs out. The sand is made of very hard bits that have sharp edges, and there are also many fine

holes between the grains of sand, so that the water runs through it readily. Thus we see that pure clay holds water a long time and pure sand cannot hold water. Now, if sand is mixed with clay the soil thus made will hold water better than pure sand and not so well as pure clay; for the sharp edges of the bits of sand will keep the fine bits of



Clay, loam, and sand molds (taken from flower pots).

clay wider apart and thus let the water through. A mixture of sand and clay is called loam.

Very few plants can live in a soil like pure clay in which water stands. Water cress and a few other plants can do so. And very few plants thrive in sand, because it holds so little water. The cactus is about the only family of plants that likes such very dry soil. But almost all plants do well in loam, which is not so dry as sand nor so wet as clay. Of course there are clay soils which have a little sand

in them, and sandy soils which have some clay, so that all kinds of mixtures may be found: sandy clays, clayey loams, loamy sands, clayey sands, etc. In clays the parts of soil are so very fine that they pack closely together, and when wet the spaces between the little soil flakes are filled with water, and such soils contain little, if any, air. In sandy soils the grains of sand are of all shapes and sizes, so that they do not fit into one another. Such soils have many spaces between the grains and when they are quite moist, as in loams, the sharp sand grains separate the fine clay enough for air space, so that loam soils contain more air than clay, though less than sand. We shall find after a while that the roots of plants must have air to do their work.

Our plants would have a hard time of it, however, if the soils in which they grow contained nothing but sand and clay. One might take sand or clay and wash it until perfectly clean, then bake it in an oven until perfectly dry, and then set plants in it, giving them all the boiled water they wanted, yet they would not live very long. This shows that plants require something more in the soil than clay and sand. Think how long the trees and weeds and grasses have been covering the land with leaves and stems, and how many animals have worked and died in the soil. All of their bodies, as well as the

leaves and stems, decay and become a part of the soil.

The animal and vegetable matter that decays in the soil forms one of its most useful parts, called *humus*. In the forest where the trees grow so thick that the wind cannot blow the leaves away the humus in time becomes a thick layer over the soil. This is what makes the ground feel soft as we walk in the woods.

It is the rarest thing to find a soil of *pure* sand or *pure* clay, for everywhere there are a great many things mixed with the sand or clay. There is always some iron and lime and there are other things which the plants require for food. That is why we seldom see a soil where no plants at all will grow.

Young wheat plant.

IV. THE PLANT AND THE SOIL

WHILE there are a few plants that live in water without being fastened to the soil, all the cultivated plants are grown in soil. The roots of the plant anchor it to its place so that it cannot be destroyed by wind. Small plants that do not rise high in the air are in no danger from wind, and yet they often have very large roots. The clover, one of the most useful of forage plants, often has roots over ten feet deep, although it seldom has stems over two feet high. So the root must have some other use besides that of holding the plant in the soil.

In the spring, when growth first begins, the wheat plant is much smaller above ground than below — its stem is smaller than its root. It will take very careful work and a good deal of digging to get all of the roots of a strong winter-wheat plant in early spring. And if we try to dig up all the roots of a wheat plant

when it is in blossom we shall have to make a big hole in the ground. But the wind does not blow the wheat plant over; it sometimes breaks the straw, but the root holds the plant in place. Why should the wheat plant have such a large root with so many branches?

If there are any woods near the schoolhouse, let us see if we can find a tree that has blown down. How deep into the ground do the roots grow? I have seen the roots of alfalfa plants go ten feet or more into the soil; and in a very dry knoll in Dakota I once took the trouble to dig out all the roots of a box elder tree, the seed of which I had planted twelve years before. The tree was little more than twelve feet high — it would have grown much taller in the same time in Tennessee — and it was about ten feet in diameter of crown. A man helped me and we were very careful not to cut any root, following each one until it was no thicker than a fine knitting needle. It took us two weeks to dig up the tree in this way. And how far do you think the roots had grown? The deepest branch was traced thirteen feet straight down, and the longest we followed twenty-four feet from the collar — the place where root and stem join — and it was then only three feet below the surface. Most of the roots of this tree were within two feet of the surface. If

we examine even large forest trees that are blown down we may observe that they do not send their roots very deep, most of the roots being within four feet of the surface. Can any one tell why?

Is the soil the same color all the way down? And why is there a difference? I suppose if you and I

An uprooted forest tree.

(Reproduced by permission of the Forest Service, U. S. Department of Agriculture.)

were to use just the right things, we could take some of the light-gray-colored subsoil, or some red or yellow clay, and we could color them just like the surface soil. If we take even a little rotten

wood from an old log, or some decayed grass and weeds and leaves, and break them up fine and mix them with the red or gray subsoil, we can change its color and also change its water-holding power. Let us try it.

But if instead of leaves we use well-rotted barn-yard manure it will not only change the color of the soil, but will make it richer and better for the growth of plants. We can take soil from a deep hole, like that thrown out in digging a well, and if we mix enough sand with it so as to make its water-holding power like loam, and then add well-rotted manure, we can grow plants in it quite as well as if we had used surface soil.

Suppose there were a very hungry boy in this school, whose mother, knowing him to be always hungry, had put a piece of pie on every tenth fence post from the schoolhouse to his home. No doubt he would eat the nearest piece first; but if some other boy had eaten all the pie near the school-house, or if the first boy were still hungry when he reached his home, I dare say he would eat the pie he found there also. Just think what a host of plants there are, and all hungry for the food the soil contains. They grow most of their roots in the dark surface soil because most of their food is there, but they almost always send some roots deep down into

the subsoil, where there is apt to be more moisture. Thus they are better able to stand a famine or a drought.

The roots of plants adhere closely to the bits of soil so they can absorb moisture from them. The young roots are covered thickly with hairs, which grow into the tiny spaces between the soil particles, and press close to the soil to get its moisture. But the old roots and the tips of the young roots have no hairs. If you pull up a very young corn or wheat plant the roots will be covered with soil. What makes it stick, and why are the root tips clean?

V. LITTLE RIVERS UNDER THE GROUND

It rained all day long at the Fruit Farm one day last January, and the next morning the sun was shining when I started to ride to school. As I passed along a hillside road in the woods, the gutter at the roadside was full of running water. In grad-

A roadside rivulet after rain.

ing, the land on the higher side was cut down about eighteen inches, and the dirt was thrown to the lower side, so as to make the road level; then a shallow ditch was made on the upper side. As I rode along I noticed a great many little streams of water

gushing out of little holes in the bank that had been made in grading. They were like springs, and I thought they must come from underground rivers. But where did all the water come from that was pouring out of the bank? What made the little rivers under the ground?

The next day the little rivers were still flowing, and the water was as clear as any spring. A few days later the rivers were all dry, but I am sure after the next rain they will flow again.

Let us talk about them a few minutes. How many branches are there in the crown of a beech tree? The crown of a tree is the part above the trunk, no matter how low the limbs may grow. If they start at the ground the little tree is all crown. And how many branches are there in the root of the beech tree? It would be hard to answer either of these questions, but every large tree has a great many branches both above and below the surface of the soil.

When next we go into the woods I want you to find a big tree and try to count the number of dead limbs in its crown, and the scars where limbs have been. Many limbs, big and little, die every year. The crown branches drop off when they die, and the root branches decay, leaving a hole where they grew.

When the rain falls in the forest it does not pack the soil as it does sometimes in fields, for the tree tops break the force of the drops, and much of the rain water follows down the limbs and trunk to the ground. The forest floor is covered with a carpet

Leaves on the forest floor.

of decaying leaves, which absorbs the rain water. As it sinks into the soil it finds the holes where the dead roots once grew, and so instead of running off over the surface of the land as would happen on a hard road, the rain water in the forest makes little underground rivers.

The water that follows the courses of dead roots

helps to make the subsoil richer by carrying down small parts of the decayed leaves and twigs from the surface. The air also passes freely into all the holes in the soil, and this is very helpful to the roots of plants.

Forest floor with carpet removed.

There are other channels for water and air besides those where roots once grew. All the animals that make burrows in the soil help to form underground rivers. The moles, gophers, woodchucks, mice, and many other little creatures that are a pest to farmer and woodsman help him a little in this way. The fish worm makes a great many tiny channels

through which air and water pass freely, and it is thus a great worker in deepening the soil and making it richer.

Now, when a forest is all cut away, and the land is turned into farms, many of the underground rivers become dry, and the rain water runs over the surface of the soil, washing it into gullies, unless the farmer uses his land very carefully. Since the trees are no longer there to put a coat of leaves on the ground every year, the farmer should try to supply something in the place of leaves. He may plow under crops of peas, grass, rye, or weeds — any kind of plants that will decay in the soil will help to keep open underground rivers. Or he may plow under the manure from the stables and feeding lots, and thus make the soil richer and keep the little rivers flowing at the same time.

VI. WHAT THE FOREST DOES FOR THE SOIL

EVERY plant does something to the soil in which it grows. It takes something out of the soil and gives something back to it. The soil is like a savings bank. Some people put in money every week, and take out very little; and the bank takes care of the money and adds to it, so that the longer a man leaves his money with the banker the more he gets. Then, some day he can take out more money than he has put in, for the money itself has been earning a little all the time, and this little is added to the whole amount. Year by year the savings increase. If a boy two years old were to begin now and put one cent a day in the savings bank until he came of age, he would have a hundred dollars, provided he drew no money out.

Now, the forest is all the time taking a little store from the soil, but it is every year putting more into it than it takes out. All through the long summer the roots of the trees are taking water from the soil and carrying it up to the leaves.

The water is never pure, but always contains certain things that the plants live upon. If you drop a lump of sugar into water, the lump soon disappears, but the water tastes sweet. The water has

taken up the sugar. In the same way, while the water is in the ground it takes up certain things from the soil which it carries into the plant. We think spring water pure, because it is clear, but pure spring water contains all the food that plants need.

The trees that grow in the forest where the wind cannot blow the leaves away act just like other plants — their roots absorb water from the soil, and this water contains different things that the trees must have for food; but such very small portions are dissolved in the water that it tastes pure to us. Spring water contains a great many things, all mixed together, and all necessary for the plants. Here are some of the things contained in spring water that plants must have in their food: oxygen, hydrogen, nitrogen, potassium, phosphorus, iron, chlorine, calcium, magnesium. You need not learn these names. They are used here just to show you how many different things spring water may contain when we think it is perfectly pure.

The water that enters the plant thus carries food, and the plant thrives on it, as we grow by what we eat.

Every year the forest returns to the soil all the leaves that grew during the season and a great many twigs and limbs that have died from want of

light. Down in the ground a great many roots also die every year. The forest covers the ground so densely that the wind cannot blow the fallen leaves away, and the shade of the trees keeps the ground much more moist than it would be if the trees were

Section through leaves and surface soil to subsoil.

wide apart, as in an orchard. So the leaves, twigs, and dead limbs lying on the moist soil soon decay, and most of the matter they are made of burns up and passes into the air. The burning is so very slow that there is neither smoke nor flame. We are apt to think that there can be no burning unless there is fire, but the fact is that the change which

takes place in the dead leaves that fall from the trees is a very slow burning. It takes several years for a single crop of leaves to burn in this way; while a fire lighted to the leaves would burn throughout the forest in a very few hours. But such rapid burning leaves only ashes, and ashes do not improve the soil so much as do leaves and twigs and fruit, which rot slowly and become mixed with the soil itself. We call the decaying wood and leaves *humus*, and it is the best gift the forest can make to the soil. It is a good plant food. It holds water like a sponge. It lets air into the soil when mixed with it. It prevents the rapid drying of the soil. All these things are good for the plants that the farmer grows, and so the forest helps not only the soil but it helps the farmer also.

It takes a great many years for the humus to form on the floor of the forest. Every leaf helps, but each leaf is so small that all the leaves that grow in fifty years or more are needed to make humus enough to improve the soil of a field.

A farmer can supply as much plant food to the soil, in the form of manure, in a single winter as a forest might give in fifty years; but a great many farmers do not manure their fields at all. They plant crops in the fields year after year, and the crops yield less and less, until the soil does not produce

enough to pay for working it. Then the farmer quits and lets nature care for the land.

What does nature do with an old field? By bad work on the part of the farmer the loam has become washed away and the clay subsoil shows here and there in the field. The crops have taken so much of the plant food out of the soil that even the weeds do not grow well in it. But hardly any soil is too poor for some kind of a weed to live in it, even though the growth is poor.

So the first few years after a field is turned out there is a growth of poor weeds, each one of which is helping the soil a little. Every weed that grows, no matter how bad it may be for our crops, earns its right to live by doing what it can to make the soil better; and in old fields, where nothing else will grow, the weeds are very useful to the owner of the land.

After a while there will appear among the weeds a few woody plants, such as greenbrier, and blackberry, and sassafras, and each one of these helps to make the soil better not only by the fall and decay of its own leaves but also by making lodging places for the dead weed leaves, so that the wind cannot blow them away.

If we go away for fifteen or twenty years, and then return, we shall hardly know the old field, for it will

(35) An abandoned field showing erosion.

be covered over with young trees of many kinds. Pine and cedar, tulip and ash, maple and cherry — a great many trees will be found in the field, and only in a few places can we see the bare soil. Almost everywhere the trees and bushes will cover the land, and every one of them will be at work making the land better by shedding its yearly crop

Sapling pines in abandoned field.

of leaves and twigs. All the time the trees will be getting bigger and bigger. In fifty years quite good-sized trees will stand in the field, making a young forest; and in a hundred years or more fine timber can be cut from the old field, and the land

will be so rich that it will again produce good crops.

But a hundred years is a long time to wait for the forest to enrich our poor soil. The better way is not to allow our crops to rob the soil. Let us every year put just a little more plant food into the soil than the crops take out. Then, if we look carefully after a few other things, our fields will never be worn out, but will become better year by year.

In the Middle West, where the forest only borders the streams, or where no trees grow, it takes much longer for nature to restore fertility to a worn-out field because there the ground cover is only weeds and grasses, and humus forms very slowly.

VII. THE ROBBER FARMER

ONCE upon a time there was a farmer who became poorer and poorer until everything he had was taken away from him to pay his debts. The crops that this farmer grew were all robbers — they took things from the soil and put nothing back. It was not the fault of the crops, however, but of the farmer; and when at last he lost all his lands the fields were not sorry, for the man that got them did not help the crops to rob, and they began to get fertile again.

When the first farmer bought the land it was all covered with forests, and the trees had made it rich. The first thing he did was to cut all the trees and sell them to the lumbermen. When he first plowed the land it was full of tree roots, and it had a dark, rich color. Part of the farm was level, but part of it was very steep. The farmer cleared it all of trees and planted corn, which he plowed and hoed. The corn grew large and strong, for it had all the food it wanted. The forest had greatly enriched the soil.

During the summer, whenever it rained, little gullies would form, and the rain water would carry the soil away, in places one or two feet wide and three or four inches deep. In all the steep parts of the field the rich top soil would thus be washed away, and neither the corn plants nor the farmer

were helped by it. Some other farmer, who lived down the slope or along the creek where the soil was lodged by the stream, was made richer, and that was all.

All summer long the corn grew and made a fine crop. When the corn was ripe in the fall the farmer cut all the stalks off close to the ground and shocked them. When he had shucked all the ears and put them into the corn crib he sold the fodder to a neighbor to be fed to the stock during the winter. The big field was left all bare; so the winter rains washed the rich top soil down the slopes; but the farmer was thinking what a fine crop he had made, and he left the land to take care of itself.

The forest had not treated the land so badly. It had taken a great deal of richness from the soil, but in the fall, when the frost came, it had covered the land all over with leaves. And in the winter many dead twigs and branches dropped off the trees, and many roots died in the ground. All these dead leaves and twigs, branches and roots, the forest gave back to the soil. But the corn plant could give nothing; since even its leaves and stalks had been carried away.

The poor farmer planted other crops on this field — wheat, oats, rye, corn — and every year he took all the crop away. In a very few years the field did

not yield so well as it did at first. The tenth crop of corn had only small stalks, and there were almost as many nubbins as good ears. The corn plants were anxious to make just as big ears as the first crop of corn had produced, but the plant food in the soil had been used up or wasted.

What should you tell this farmer to do? I should tell him to go into the forest and learn the lesson it teaches. The plant food in the soil which he has carried away in the form of crops must be replaced in the form of manures. The forest uses leaves and roots and twigs and branches for manure for the soil. What should the farmer use?

VIII. WEEDS

WHAT is a weed? In one story it was said that if the farmer plows under a heavy growth of weeds it keeps the little rivers in the soil open and thus prevents the rain from making gullies in the fields. When weeds are allowed to grow high for this purpose, they are useful and may be called a kind of crop. Indeed, in the northwest, where wheat is the greatest crop, most farmers allow weeds to grow in the fields instead of wheat, once in four or five years, on purpose to plow under. They call the weeds a fallow crop; and by plowing the land when the weeds are in bloom they prevent weed growth the next year and improve the texture of the soil.

Corn cockle, a weed of the wheatfield.

Morning glory, a weed of the meadow.

In Tennessee cornfields one often sees a great many morning-glory vines, and in the morning when the flowers are all open they are very pretty. Is the morning-glory a weed? Two years ago I grew some bachelor's buttons in the garden, and every visitor admired their blue flowers. The bachelor's button, like most plants, has several names. The Germans call it the corn flower, and some people call it ragged robin. Last year I planted other things in that part of the garden, but the bachelor's buttons had sown their own seed

in the land, and it took a great deal of hoeing to get rid of them. Were they weeds?

Last year a corn plant came up in the rose garden, and the gardener allowed it to stand. It was a weed, just as truly as if it had been a purslane or a dog fennel or a sour dock.

When the morning-glory grew in the cornfield it was out of place, for the land was intended to produce a crop of corn. And when the corn plant appeared in the rose garden it was equally out of place, for it was the business of the garden to yield a crop of roses.

A weed, then, is a plant that is growing where it is not wanted. The dictionary tells us a weed is a plant that is useless or troublesome; and some one says a weed is a plant for which man has not found a use. Let us think of all these meanings in trying to find out what a weed is.

In a cornfield, the morning-glory is a weed, but it is a flower to be cared for if planted where it will shade the kitchen window, or the porch where the morning's work is done. It seems odd to call the useful corn plant a weed, but there are a great many useful things that become nuisances when out of place.

Every plant that comes up in a wheat field except the wheat itself is a weed, and the same is true of any other plant in any field devoted to a special

crop. The pastures and meadows are apt to have many kinds of weeds, and all of them are much safer among the grasses than they would be if growing among corn plants. Why?

Dock, a weed of the meadows.

The farmer must keep up a constant fight with the weeds, or they will use more of the plant food in the fields than his crop can spare. The fields ought to be rich enough to support the crop and have something left, but it would be foolish to give what is left to the weeds. And if it should happen that weeds spring up in spite of the farmer's care, the best thing to do with them is to plow them into the soil, where by decaying they will help the land;

only this should always be done before they go to seed. When one plows ripe weeds under one really sows a crop that is very hard to overcome.

Weeds are troublesome not only because they take food from the soil but also water. Weeds require water just as crops do, and in dry seasons, particularly, the weeds should be kept out.

Some weeds are very aggressive, and if left to themselves capture a field or a meadow in a single season. But these are usually watched for by the farmer, and he seldom lets them get a foothold. I suppose that the sneaking kind of weeds that slip in among the grasses in the meadow land, or hide among the small grain, really cause the most loss, for no one realizes how much they are taking from the crop.

When the meadow gets very weedy it must be plowed, and corn and other crops that need hoeing must be planted in the field. Corn, cotton, tobacco, potatoes, and vegetables are good crops to plant on grass land, for the tillage they require is the very thing necessary to kill the weeds.

The weeds could teach us many lessons, but usually we are too busy killing them to study them very much. If we study their habits we shall discover better ways of fighting them. A great many farmers who try to kill weeds only succeed in trans-

planting them. I have seen men wait until the cool of the evening to hoe the weeds in their gardens. That was easy for the men, but had the weeds been cut off just below the surface of the soil after the dew had dried in the morning, they would not have sprouted again after the next rain. I have also seen boys hoeing in weedy gardens, where they

Ox-eye daisy, a weed of the meadows.

would cut off the weeds just above the ground, or dig them up bodily by making deep gashes into the ground. Neither is a good way. In the first case buds near the ground are sure to grow, and in the second a rain will set the plants to growing again.

The best way to kill weeds by hoeing is to cut just far enough below the surface of the soil to cut through the root, and then turn the stem base up, so

that it will wilt quickly. Deep hoeing often leaves enough soil attached to the root above the cut to enable the plant to grow. Hoe shallow, from one half to one inch deep, and hoe every bit of the surface. This will kill all the weeds, make a dust mulch on the ground, and save the moisture in the soil for the crop.

No single hoeing will kill all the weeds, for the seeds do not all sprout at one time, and we no sooner get rid of those that are big to-day than little ones grow up which must be hoed next week.

For field work cultivators with many small teeth are the best weed killers, but they can only be used to advantage while the weeds are small. The weeds in a corn crop should never be allowed to grow until they are so big that a double shovel cultivator is the only thing that can root them up. The cornfield is best cultivated with a spike-tooth harrow until the corn is at least four inches high.

Now, it would be a good thing for us to learn the names of all the weeds we can, and make a collection of them in three sizes: in babyhood, in flower, and in fruit. And let us be sure to get the roots as well as the tops. In doing this I think we can find out what the business of the weed is.

IX. WHAT THE RUSSIAN THISTLE DID

THIS is the story of a foreigner. There are a great many foreigners in our fields, but most of them have lived there so long that we can hardly tell them from the natives. But this foreigner made such a commotion in so short a time that she was very much talked about. Most plants (we are talking about plants, you know, not about people) come into a new country very quietly, and some of them slip in hidden among others. That is what the thistle did.

Nobody wanted her. She was not liked in Russia, but she was sly, and slipped into the wheat fields and hid her seeds among the grain, and so got into the grain sacks. Somebody bought a lot of Russian wheat to plant in Dakota, and the thistle was bought, too, though the buyer did not know it, and everybody was sorry when the discovery was made.

Now, the thistle had had a pretty hard time in Russia, and she was glad to get away. She took her place in the seeder as if she had a right there, and she no sooner found herself in the ground than she pushed her head above the surface and took a look around. It was a fine country. There was plenty of moisture and plenty of food, and she

enjoyed her life very much, growing fast and strong. She was modest at first and nobody saw her.

A great many plants besides wheat grew in the fields of Dakota. There was the mustard, which had big leaves and bright yellow flowers. In some fields there were so many mustard flowers that you could not see the wheat — eighty acres of brilliant yellow! And there were the fire weed and the cockle, and many others. The farmers on the look-out for these might be excused for not seeing a plant whose leaves were less than half an inch long, and spine-shaped at that, and whose flowers were so small that one had to search for them, hidden close to the stem in the axils of the leaves.

So the Russian thistle grew unmolested, and it happened that some plants escaped the reaper, and they stood quietly until the end of the season, ripening their seed. Unlike the mustard, they did not hasten to drop their seed and they each produced a great many, for almost every leaf hid a flower, and every flower produced a seed. But in the fall, when the wind began to blow, the thistles were wrenched loose, and began rolling over the fields before the wind. As they jumped along over the plowed land the seeds were jolted out, but the thistle hated to part with them, so she did not drop them all at once. It took a great many jolts before they were all set

free, and the wind had carried the thistle several miles, so that she sowed her seed over a big stretch of country.

There were few fences in Dakota at that time, and it is a level country, so the big, bushy thistles rolled for miles and miles, scattering their seed as they went. The next spring the farmers began to notice a new weed in their wheatfields, and because it had spiny leaves they called it a thistle, and soon, when it was learned whence it came, it was given the name of Russian thistle. As a matter of fact, however, it is not even related to the thistle family, but belongs to the pigweeds. And how it spread! In a very few years it became worse than the mustard, and the State passed a law against it.

For a few years the farmers were in a panic, and then some one discovered that the foreigner could not live in a field where the cultivator was kept going, and the farmers really owe a vote of thanks to the Russian thistle for forcing them to rotate hoed crops with small grain.

X. THE PLANT'S BUSINESS

I WONDER why it is that so many men treat plants as if they were not alive. It seems as if they never thought about the life of the plant until they tried to kill it. They know that horses, cattle, sheep, and pigs are alive, and they give them a group name, "live stock." No doubt they think of plants as "dead stock." It would be no more foolish than to treat the plants as many men do.

I like to think of plants, as I like to think of boys, as always very much alive, every one with business to attend to, and each doing his best at the work. I think you will agree with me that the peach tree and the apple tree have business of their own, and when they give us fine crops of fruit we are glad they have worked so well. And we are sure that the corn plants and the cotton plants have done a good summer's work when we gather good crops of corn and cotton in the fall. But have not the cocklebur and the ragweed also attended to their business during the entire season?

Sometimes I think that man believes that all the plants were made for him — that the business of the plants is to be useful to man. But a great many questions rush to my mind. If that is so, why does he find so many of them useless? Why

does he use them in so few ways? And so we may well study this question: What is the plant's business?

The boy that gathers hickory nuts enjoys the exercise and likes the nuts. I wonder if it ever occurs to him that there are other nut gatherers besides himself, and that the old hickory tree thinks more of them than of him? When I was a boy we used to devote a day every year to gathering wild plums. Father and mother and all of us children would go up the river several miles in our boats, and when the season was good we would get all the plums we could use. There were wild plum thickets which fruited freely. Many plums were too poor to use, but some were very fine. We all have gathered luscious blackberries in the wood lots and pastures, and along the roadside. Was it the business of hickory and

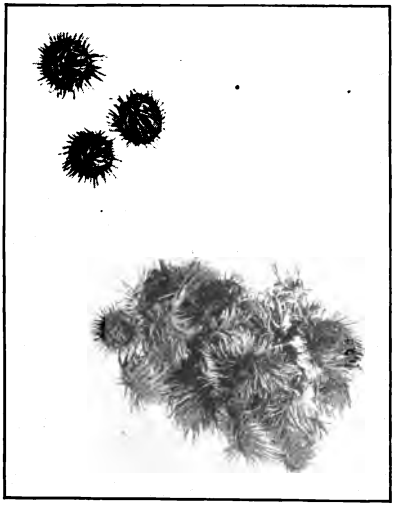
Blackberry in fruit.

plum tree and blackberry bush to ripen their fruits for us?

Away up in the Canada woods where the birch tree is so common that men forget its beauty, when early spring comes the air is full of tiny seeds that come spinning on their double wings to the earth; and if the wind catches them it carries them far from the parent tree, and may even land them miles away. You may see the same thing happen in the pines. Then all of you know what thistledown is; and if you have not made fairy balls of milkweed seed, all I can say is you had better learn how, this very summer. I have seen little girls ask the head of the dandelion if mother wanted them, by blowing it three times, and if all of its hair was blown off in three blows, home they went. Do you suppose the business of the dandelion is to tell little girls when their mothers want them? If not, why do their heads have hair, all white and silky, that blows away with a breath?

Dandelion in fruit.

Then there are the burdocks and the cockleburs and the beggar's lice. I have gone through the woods in the fall and come out with my clothing so covered with beggar's lice that it almost seemed as if the plants were angry with me and had made a half hour's work necessary in order to settle some grudge. I wonder if the burdock and the cockle hate cows? Is it the business of beggar's lice and burdock to bother me and the cows?



Burdock seed.

If these are the duties of plants, I must say I like the nut trees and the fruiting plants vastly better than some others I have mentioned. But in going through the mountains one sees thousands of nut trees, and very few people, and who does not know what vast quantities of berries go to waste every year? Are the plants so wasteful as to produce nuts and berries that are not used at all?

I think we must find some other business for the

plants than being useful to man. They are useful to us in a great many ways, but then, turn about is

Burdock.

fair play, and we are useful to such plants as befriend us. Indeed, I have seen cockleburs growing

in cornfields so happily that it almost made me think their best friend was the farmer.

Besides we have already seen that plants are useful to the soil as well as to man. The forest improves the soil by giving to it every year a crop of leaves and twigs. And in the prairies and the plains the grasses help the soil in much the same way. Furthermore the plants are as useful to animals and birds as to men. Every animal that eats grass and grain and fruit, and every bird that lives on seeds, is dependent on the plants for food.

XI. BUDS AND SEEDS

If we have all decided what the plant's business is we may find out something about the means it uses in doing its work. All the plant has to think about is how to make more plants of its own kind, and it begins working with this end in view very early. In order to have as many perfect seeds as possible, while it is yet in flower, it does what it can to attract insects, which help in making its seeds perfect. The insects do a great deal of work for the plants, but the plants pay them well. They store perfume in their flowers, and what is even better, they store honey there, to pay for the insects' work.

But to me the strangest thing the plants do is to hang out bright flags — red and white and yellow and many other colors — to attract the insects' attention. You know the bees and flies have a great many eyes, and they can see a long way. One of them may be flying along for exercise, when he spies the pink banner of a wild azalea, far across the creek. He says to himself, "I did not know Miss Azalea was awake yet, but I see her waving a flag, and I will go over and visit her." And when he reaches the azalea, that lovely flower has a dish of the sweetest-smelling honey for him. No wonder

he is glad to work a little for her. Let us watch along the road as we go home and see if we cannot find insect visitors among the flowers. The weeds are just as good friends of insects as the other plants.

Now, some plants do not care for the insects. They get the breeze to do their work, and they do not have to pay him, so they do not take the trouble to hang out flags, nor store honey in their flowers. All the plants of this kind save the material the flags are made of to use in other ways. The wheat, corn, grasses, and many of the trees have greenish-colored flowers, because they do not need the help of insects. But the clover and rape and cotton and many vegetables brighten their flowers to call the insects. And the wild rose is red and sweet, not because we love it, but because it thus lures and repays its insect visitors.

A little while after the flowers fade, a great many seeds take their places on the plant. The plants have almost as many kinds of seed and seed covers as they have flowers. The apple plant covers its seed with juicy flesh in a bright red skin, and it gives the flesh and skin to you and me for carrying its seeds out of the orchard and dropping them on the ground. The wheat plant covers its seeds with a strawy chaff that is troublesome to thresh off; and is of no use to us at all; but the wheat plant

knows well that men like its seed to make flour of, and will be sure to save enough to make more wheat plants next year.

The nut trees know that squirrels and boys will carry off most of their seed, but they also know that squirrels have short memories, and forget where they have made their storehouse. The dogwoods feed their berries to the birds, which carry the seed away and drop it to grow into dogwood trees.

Dogwood berries.

Now I think we can see why the beggar's lice and the cocklebur bother men and other animals that pass their way. The maple and the elm drop their seeds into the stream over which they love to grow, and the willow and the poplar give theirs to the wind, to carry where it will.

Have you thought what a lot of work the plants give men and birds and beasts and creeks and wind

to do? Men are not the only planters. I should not be surprised if the birds plant more seed than the farmers. All the sycamore and willow and cottonwood trees along our rivers were planted by the streams, while the wind has helped to plant the pineries.

Beggar's lice.

So you see the plants have many friends to call upon; and the reason they make themselves useful to us is that we, in turn, may help them to increase in number and in size, more than would be possible in their wild state.

Every seed is a little plant that only needs heat and moisture and air to help it push up a stem and down a root, and there it is, alive and working, like its parent plant. And every bud is a little plant too, only it gets its moisture through the stem on which it grows, and when it pushes, it makes a new

branch instead of a new plant. Many plants increase in number from stem-buds as readily as from seed-buds, and some few have ceased making seed growing entirely from stem-buds. The potato, sugar cane, and banana form few, if any, seeds. The seedless raisin is made from a grape which grows only from stem-buds. The tulip and most other bulbs form very few seeds, but grow from stem-buds.

So plants have two ways of making new plants — by seeds and by buds. Can you mention some farm and garden crops that are grown from seed, and others from buds?

XII. WHY DO WE PLOW?

MAYBE I ought to ask why we see so many kinds of plowing. When I see three big, strong horses hitched to a good plow, going along at a brisk walk, pulling hard, I like to go over into the field and watch the work. And if I find a second team, stronger than the first, following in the furrow with a subsoil plow, I am sure that a good beginning is being made toward a good crop. But when I see one little horse hitched to a little plow, I am just as sure that if the crop turns out good it will be not because of, but in spite of, the plowing.

A plow at work.

The little plow hardly turns a furrow more than three inches deep. The man behind it is not careful to make his furrows straight and even, and often there are little unplowed spaces left. There is very little good in this kind of plowing. It leaves the top soil almost where it was before, and it does not

loosen the lower soil. The only help it is to the farmer is that he gets enough loose earth by that kind of plowing to cover the seed when he puts in his crop.

The man with the big plow and the subsoiler does a great deal more than this. His surface plow is turning a furrow ten inches deep, and when the furrow is finished the top soil is at the bottom of the last furrow and the earth is crumbled loose all the way through. The subsoiler following loosens the earth six inches deeper, without moving it from its place. When the field is done, the earth has been stirred to a depth of sixteen inches, and it is loose, so that the air goes through it almost as freely as it passes over its surface. Why do we plow?

A subsoil plow.

I think a little observation just after a rain will tell us one reason why. The rain comes down on the pike road, the roadside, the meadow, and the

field; the water quickly disappears from the newly plowed field, and it takes a long, hard rain to make little streams on its surface. The meadow does not soak up the rain as fast as the plowed land, but the

Poor plowing.

water does not stand on the surface there as it does in the dirt road; while on a hard pike it takes but a very little shower to leave pools of water in the ruts. The dirt road has been packed by travel until it too is very hard. The meadow, with its thin covering of grass, has protected the soil from packing and baking, but it is not so loose as the plowed land, in which, if the work was well done, the earth

has been crumbled to a depth of ten inches or more.

When well plowed, then, the soil will absorb a great deal more rain water, and will allow much less to run off in surface streams, than is the case in land that is not plowed. Shallow plowing does but little

Plows.

good, because it does not make a deep enough layer of loose soil, and often the soil loosened in shallow plowing is carried away by heavy rains.

In times of drought the land becomes hard as well as dry, and does not so readily absorb the rain as when it is loose. Deep-plowed land can be kept more open than land plowed shallow, and so resists droughts better.

The rain that is absorbed by the surface layer of plowed land sinks in the air spaces of the subsoil. If the field has been subsoil-plowed the subsoil is loose and open, letting the water sink easily into the lower depths, where it finds pathways made by dead roots and earthworms, and thus it gets deep into the ground, and is all saved to the field.

The best time to plow depends not so much on the season of the year as on the condition of the soil. If the ground is very dry, as is often the case in September, the soil will not crumble when turned, but will break into large clods, in which condition it will not absorb the rain easily. On the other hand, especially in clay soil, if the land is plowed when too wet, it will at first be sticky, and when dry will be very hard, making it almost impossible to fine it down with disks or harrows. Often land plowed when too wet remains in bad condition throughout the season. The best condition of the soil for plowing is when it is dry on the surface and fresh below. It will then crumble under the plow, and can be perfectly turned, and is easily fined with the disk harrow and the spike-tooth harrow.

Whenever stubble land is to be plowed the sooner it can be done after the harvest the better. The land should be so well turned that all the stubble is covered. This can be done by taking narrow, regu-

lar furrows. The summer rains will help rot the straw in the ground, and when well-rotted the straw turns into manure, like the forest leaves. It adds very little to the richness of the land, but makes clay easier to work, by keeping the soil particles from running together. For the same reason it is a good plan to plow under the weeds, grass, cowpeas, or any other green crop.

When through overcropping land has become very poor, cowpeas, crimson clover, or other plants of a similar nature, are often sown for the special purpose of plowing them under as a fertilizer.

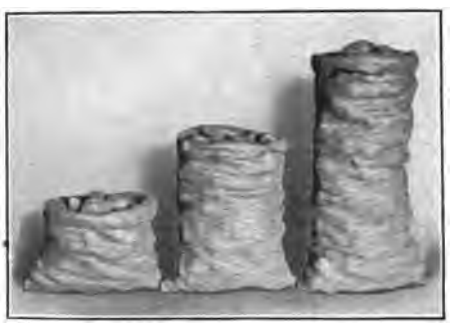
XIII. GIVE THE CROPS PLENTY TO EAT

HEALTHY plants are like healthy boys and girls — always hungry. And when you have thousands of corn plants in one field you may be sure that they will need a great deal of food. Feeding a corn plant and feeding a boy are two very different things, because the plant and the boy do not eat in the same way. The boy must have his food prepared, and he wants it at least three times a day. If the farmer had to feed a meal to each corn plant three times a day, what a task he would have! But the farmer only places food for his corn crop once in the whole year. And sometimes he forgets or neglects to do even that, and then the poor corn plants have a hard time, and yield only nubbins instead of good, big ears.

We feed our crops when we fertilize the land in which they grow. Some farmers use barnyard manure to fertilize their fields, and some buy fertilizers. When the manure is carefully handled it is not only a good plant food, but it improves the soil as the forest leaves do, and the green crops that are plowed under. When the fertilizers are bought it is more important to plow under cover crops than when barnyard manure is used.

The plants need a good many kinds of food, but

there is always plenty of almost all kinds in the soil. The three kinds of plant food that must be bought are nitrogen, phosphoric acid, and potash. These can be bought already mixed, or they can be had separately. Barnyard manure contains all of them, but if we want to buy nitrogen for plants, we get it in the form of nitrate of soda or cotton-seed meal. If we want phosphoric acid, we buy acid phosphate or ground bone, and if we want potash, we get muriate or sulphate of potash or wood ashes. There are many other fertilizers besides these, which contain more or less nitrogen, phosphoric acid, and potash. These things are to the plant what meat and bread and vegetables are to boys and girls — they are the food by which the plants grow. It is not necessary to remember their names, but we must remember that the plant cannot live without them.



Sweet potatoes in sacks, showing effect of manures.

When we want to make our pigs and cattle grow well we feed them all they will eat; and we must

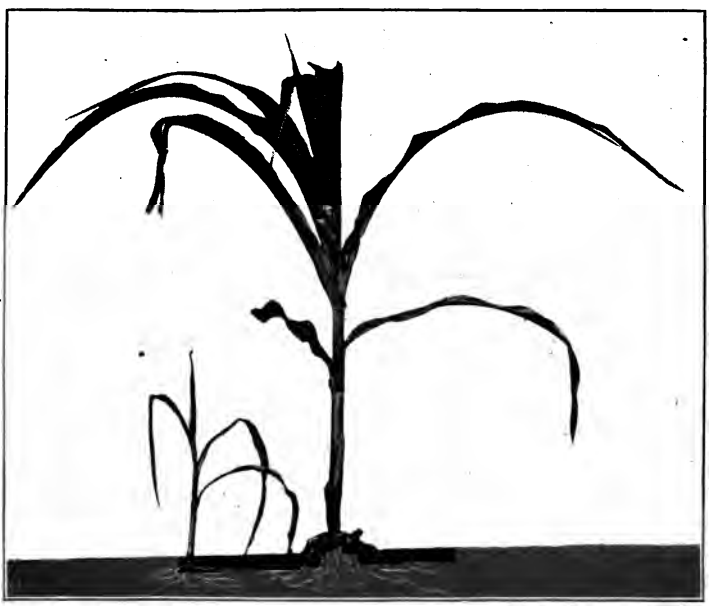
have the soil rich in plant food to make the plants grow well. The plants take a good deal of their food from the air, but we cannot control that — there is always plenty of the air food.

Well-fed corn plants.

When we plant corn we expect a crop of grain. The plant is just as anxious to make a crop as we are. The plant's business in life is to produce seeds, and scatter them widely. Every grain of corn is a seed that contains a tiny bud and a great deal of stored food for the bud to use in growing until it can make roots and leaves. And every bit of the stored food in the seed must be taken by the plant from the soil and the air. If there is plenty of food the plant will make big, plump grains of corn, and full ears; but if there is so little food that the plant is almost starved, it cannot do its work of seed-making any more than

a starving man could do his work, whatever it might be.

But I can think of plants standing in rich soil and starving to death, just as I can think of people



Small plant starved: it grew near a roadside tree. Large plant well fed; from center of same field.

who are sick and cannot eat, though they have plenty of food. To use its food, the plant must have good roots and good leaves. The plants live entirely on liquid diet — they eat nothing but soup! And the soup they eat is water just as it comes in

the ground, with the things that are dissolved in it.

When the rain is soaked into the soil, it takes up all the plant food it can — nitrogen and phosphoric acid and potash and a great many other things.

Well-fed cowpeas.

But all of them put together are not enough to give the water any taste; it is like pure spring water. If there is plenty of fertilizer in the soil, though, enough of it will dissolve in the water to feed the crops well.

Now, the soil that is best for plants must contain air as well as water. The very best condition is to have each grain of soil covered with a film of water,

and wherever the grains are a little large, the spaces between them will be filled with air. In this condition the roots grow readily, pushing themselves between the soil particles, and using both the air and the water in the soil. But in wet soil the air spaces have been filled with water, and the roots

Starved cowpeas.

cannot work without air. They may thus stand in rich soil and starve to death. Whenever a cornfield is flooded, the leaves turn yellow, and that is a way the plants have of telling us they are starving for air at the root.

So, too, in times of severe drought there may be plenty of food, but there is not water enough to take it into the plant.

See how very much like people the plants are!

XIV. SOWING THE SEED

I WONDER how many seeds the plants sow every year. I am sure that the ox-eye daisy alone sows millions and millions; and when I think of all the flowers, and the grasses, and the weeds, and the trees, and the farm and garden crops, there must be more seed sown every year than there are coins for all the money in the world.

If you could count the seeds that ripen on a single radish plant, you would have a big job, for I dare say there are hundreds. And if the radish is let alone it will sow every seed it has. But it would not plant them as the gardener would. The radish plant can not plow and harrow and put its seeds in a drill; it must simply drop them from its pods, and then leave them for nature to take care of.

We have found in a previous story what strange ways some plants have of getting their seed spread abroad. Wheat and corn and the vegetables are lucky enough to be very useful to man, and need not depend on wind and beasts and water to carry their seeds away and plant them. But none of the wild plants expect help from man. And so, in order that each plant may have at least one of its seeds to grow, it sows hundreds in the hope that one may fall in a good place and get a chance to live.

The wild plants sow millions and millions of seeds every year, and most of these fail to sprout. Of those that grow, very few live to bear seed. This spring, on May 6, I found one hundred and seventy-three little cherry trees just started from the seed, on one square foot of land beneath a wild cherry, and there were a great many other plants growing with them on that one square foot of land — ox-eye daisies, plantains, wild lettuce, several kinds of grasses, and other weeds. How many of these cherry trees do you think will live to bear fruit?

Now, if each of the little seedling plants had been given enough room to grow in and plenty of food, all might have lived to bear seed. That is good farming: to give each plant plenty of food, and the right surroundings, and room enough, so that it may grow as large and strong as it will.

Although the plants themselves do not sort their seed, we do it for them. Instead of planting every grain of wheat, as it comes from the threshing machine, we plant only the plumpest grains. The big grains contain more stored food than the small or shriveled grains, and the little plant in the big grain will have the best start, and usually it will make more and better seed than the small grains.

But the little plants, as soon as they come up, must have room for their leaves to spread out to

the light, and for their roots to grow in. So if we sow the seed thick we must soon thin the plants by taking part of them out.

Wheat — big and little grains.

Why do we transplant tomatoes and cabbage, and why do we not transplant wheat and oats?

Suppose a farmer were to sow five bushels of good wheat to the acre, instead of five pecks, which is enough for a good crop if the soil is the right kind and in good condition. He would use four times as much seed. Would he get four times as large a yield?

When we sow corn for ensilage we drill the seed in rows, so the plants stand about six inches apart in rows three and one half feet apart; and the crop is a great yield of leaves and stalks, but are there many large ears?

You see, then, that a great deal depends upon getting the right amount of seed for a crop into the ground. We must sow the *best* amount of the *best* seed, at the *best* time, in the *best* way.

What are these four *bests* for wheat?

The plants do not cover their seed with soil, but we must do it for them. Many plants try their best to cover their seeds with leaves, but the wind blows the leaves away and the seeds are left to dry.

We know that the seed must have moisture to sprout, so we cover the seed with soil and pack the earth firmly upon it. If the seed is sown too deep, the food it contains will not last long enough for the little sprout to reach the surface, and it will die.

I once planted some wheat grains in blotting paper and they taught me some things that every farmer should know. Ask the teacher to show you how to make a blotting paper garden.

Some farmers sow wheat broadcast and harrow it in. Others sow it with a press drill. Which is the better way?

We know that the seed must have air as well as moisture in order to sprout. Now, if the land is wet, all the spaces in it are filled with water, and so we should never plant seed in *wet* soil. But if the land is dust-dry, while it contains plenty of air it has not enough moisture for the seed to sprout. So the soil should be neither wet nor dry, but just between, when we call it fresh.

XV. ROUND AND ROUND THE FARM

LET us make a picture of a farm on the blackboard. In the center we shall mark off five acres for home, garden, and feeding lots. Then we shall make a line each way from the middle of one side, passing through the home lot and reaching to the center of the opposite side. We shall thus divide the farm into four fields, which we may call A, B, C, and D.

Now I want you to help me drive the crops from one field to another in regular order, round and round the farm. It does not make any difference how we start, but there is a best way of arranging our procession. If this year we have small grain in A, corn in B, pasture in C, and meadow in D, next year there should be meadow in A, small grain in B, corn in C, and pasture in D. In the third year there should be pasture in A, meadow in B, small grain in C, and corn in D. In the fourth year there should be corn in A, pasture in B, meadow in C, and small grain in D, and this will complete the first round. The fifth year the fields should be used as they were when the rotation began.

Just at first, it seems as if it were a good deal of trouble to change the crops from field to field every year; it would be much less bother to plant corn in

the same field ten years in succession. And when a field is seeded to grass, which grows well for several years without being disturbed, why should we leave it in grass only two years at a time — the first year for hay and the second for pasture?

I know two boys whose home life is very different. One has meat and bread and butter and potatoes, every meal, and nothing else to eat. He gets tired of having nothing but meat and bread and butter and potatoes, and often his stomach gets out of order. He is not a very strong boy, and I am afraid it is because of the sameness of his diet.

The other boy never knows what his next meal is to be, for his mother gives him vegetables and fruits and eggs, as well as meat and bread and butter and potatoes. He does not have any more food than the first boy, but there are so many kinds of food that he does not tire of it, and he is strong and healthy.

We do not all relish exactly the same food, nor do we use the same amounts of each kind. It is very much the same with the plants. It may be that the hay crop does not take the same amount of nitrogen that the corn crop needs, and when the pasture is plowed under it makes the soil quite different from what it is when the corn stubble is turned, because there is such a mass of grass tops to rot in the soil.

If instead of grass we use cowpeas for a hay crop, while it is true we must sow the seed each year, yet they make a very heavy forage crop, and they enrich the land merely by growing in it. Neither corn nor other hoed crops can do this, but the clovers and cowpeas, soja beans, velvet beans, and the pod-bearing plants generally, take nitrogen from the air as well as from the soil. Nitrogen is the most expensive of all fertilizers; and where clover or alfalfa or cowpeas are grown, all the nitrogen that is stored in the stems and roots of the plants at the time the land is plowed becomes food for the next crop.

You will notice that I let corn follow pasture, and if the pasture is of clover or peas, the corn will get all the nitrogen their roots and stems contained. The corn is a very greedy plant and sends its roots far and deep in search of food. Clover and alfalfa are even deeper-rooted than the corn, and they thus prepare the land better for corn than any other crops can. In the same way the corn, by its deep rooting, puts the soil in good condition for small grain. The grasses like a firm seed-bed, and may be sown with small grain, growing in the shade of the grain crop until it is harvested. So you see there are good reasons for deciding the order of the plants in the rotation. If potatoes, cotton, or other crops that requires cultivating, are to be grown, they

should be given a place with corn, and of course all kinds of small grain may be grown in the same field.

One of the most helpful things in a rotation is the year that the field is in pasture. The animals drop manure all over the field, and when the pasture is turned under, the manure adds to the fertility of the land. By this plan, every field of the farm is fertilized by a manure which both enriches the land and improves its texture. The use of a field for pasturage one year in four does not mean that no fertilizers will be needed. The small grain crop should have a dressing of fertilizer, and if the land is poor, a good dressing should be spread on the pasture before it is turned under for corn.

But the lesson to be remembered is that it is best for all crops to move from field to field, round and round the farm, in regular order; corn, grain, grass, pasture, over and over again.

XVI. STIRRING THE SOIL

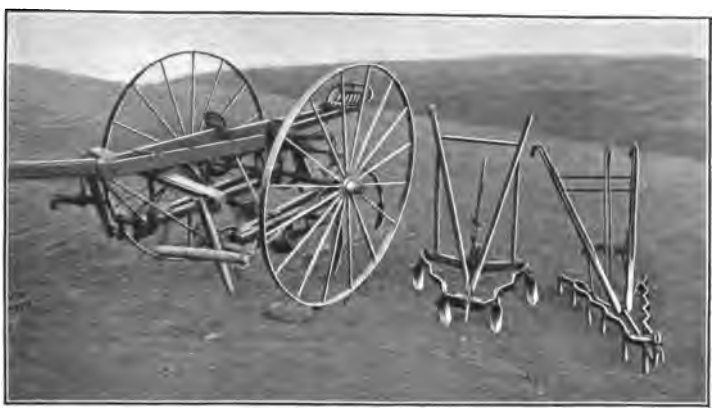
THERE are a great many boys who believe that the only reason why we cultivate the cornfield is to kill weeds, and so keep the food that is in the soil for the corn plants.

But I have seen cornfields that were badly in need of cultivation in which very few weeds were growing. We cultivate, or stir the soil, in many ways, and always our chief reason has something to do with the moisture of the soil. Sometimes when the land is too wet, we stir the soil deeply to help dry it out. When it is swampy, it may even be necessary to ditch it, or put tile drains under the surface.

As a rule, however, we stir the soil to help it absorb and hold moisture. I have told you that plowing, which is one form of stirring the soil, if well done, helps the land to absorb a great deal more rain water than is taken in by unplowed land. All the little open spaces in the plowed land fill up with water before any begins to run off the surface. Within a short time most of this water seeps into the lower soil. The land gradually dries, because the air is drier than the soil, and water passes from the land into the air exactly as it passes from water. If you fill a shallow pan with water and set it in the sun, in a few days it will all have disappeared. But

if you put a board over it, the water will last a long time.

You know that the rain comes from clouds, which are made principally of water that has been absorbed by the air from the sea. But all the time the air is also absorbing water from the land. First the top



Implements for stirring the soil.

soil becomes dry, and then in times of drought the subsoil to a good depth may lose nearly all its water into the air.

But if you cover fresh soil with a deep layer of straw or leaves, it remains damp much longer than uncovered soil. And I want you to see, if the road is dry when you go home to-night, whether the cultivated land in the cornfield is equally dry. In some parts of the country, where they have

plenty of straw, farmers plant their potatoes on the surface, or barely cover them, then cover over the entire field with straw. The potato tops grow up through the straw, which mulches the land, keeping it moist, and the potatoes form between the soil and the straw. When they are ripe they are perfectly clean, and the more easily gathered because they are grown on top of the soil instead of under the surface.

But we can not have straw and leaves enough to make a good mulch over a big field, so we try to make a mulch of the soil itself. We call it a dust mulch, and we make it by running a fine-tooth cultivator through the soil to a depth of about two inches. This lets the air in, and fines the earth so that it dries out quickly, making a dust.

Many farmers go over their corn and small grain two or three times with spike-tooth harrows, or with wire-weeders, when the young plants are first up, killing a great many weeds, and at the same time covering the land with a dust mulch that prevents the moisture from getting out into the air.

I have told you that the soil is made up of a great many very small bits, each covered with a thin film of water. The dry air absorbs the moisture from the topmost soil particles, and then takes the moisture from the ones below, and very soon the layer of

soil in which the roots of the corn are growing is dried out. Now, if we can put a layer of dust between the corn roots and the dry air, it will check

Making a dust mulch (weeder at work).

the drying out of the soil exactly as a layer of leaves or straw would.

We cultivate our crops to keep the surface as near dust as possible in dry weather. There is a great deal more need of cultivating in dry weather, for it is then necessary to save all the moisture the land contains for the crop. By simply keeping the cultivator going, crops have been saved from drought.

Single and double shovel cultivators are the poorest implements that can be used for this work, for they ridge the surface, causing it to dry more rapidly than a smooth surface, which is formed by using wire weeders and spike-tooth cultivators.

If weeds get a good start in the field, the fine-toothed machines are not so good for rooting them up as the larger ones, but the regular use of fine-toothed cultivators prevents the weeds from getting a start and so saves both the food and water the weeds would use for the crop.

Stirring the soil permits the air to pass into it freely and thus helps the plants to grow, for the roots of plants need air in their work. Changes take place in the soil when the air goes through it freely, making it richer in plant food.

So a very large part of the work of the farmer is plowing and cultivating and hoeing — stirring the soil.

XVII. THE HOED CROPS

WHEN you read the title of this story I wonder how many of you will know what is meant by hoed crops. We hoe cabbage and tomatoes. Do we hoe wheat and peas? Do we hoe the grasses? The gardener and the farmer give different meanings to the word *hoe.* To the gardener it means stirring the soil around vegetables. All the boys know what a hoe is, and most boys dislike it, for somehow the garden always needs hoeing just when there are so many other things to be done — pleasant things, like fishing and hunting and swimming.

The market gardener uses a wheel-hoe instead of a wooden-handled hoe, and by pushing it ahead of him he can stir the soil as fast as he can walk. It is a splendid machine, and one can do more and better work with it among many plants than can be done with a common hoe.

In large market gardens there are horse-hoes, cultivators with five, seven, nine, or more teeth, which are movable and can be arranged to do deep or shallow work.

Of course more work can be done with the horse-hoe than with the wheel-hoe. The next machine for hoeing is a farmer's implement, the double cultivator, which straddles a row of corn, is pulled by two

horses, and has spring teeth, or shovels. With this the farmer can hoe several acres in a day.

So we see that every kind of crop that needs to have the soil cultivated while it is growing, is called a hoed crop. Corn, cotton, tobacco, and sorghum, as

A wheel hoe.

well as beans, peas, melons, onions, radish, and cabbage, are hoed crops.

There are many things which all kinds of hoed crops need alike, and that is why we find ourselves talking about corn and cabbage in the same story.

All the hoed crops do best in land that has been well fertilized, well drained, and well plowed. They

all need a great deal more hoeing in the early part of the season than later on. When the plants first come up in the spring, the soil is not so warm as it becomes later; but hoeing the soil lets the air in and warms it, and air and warmth make the little plants grow faster. Then, as you know, all the weeds have sown their seed in the fields before the farmer puts in corn or cotton, and it almost always happens that the weeds start before the crops do. Hoeing kills the weeds, but one cut of the hoe will kill hundreds of weeds in April which by June would require a sharp stroke each; and in the meantime the weeds would have robbed the crop of a good deal of food.

By giving the crops a good start, we help them to form big roots, which are their food-gatherers, and big leaves, where their food is digested. All that corn and cotton put into ear and boll is gathered by roots and digested in leaves. So the first thing is to make them strong.

After the plants have reached full size, no hoeing is done. Maybe you think the farmer lays by his corn because it is too big to cultivate, but that is not the reason; for he might make the rows farther apart, and then he could plow until the corn is ripe. The real reason is because it is time for the corn to stop growing so fast and begin to form ears. The corn seems to like to grow just as tall as it can. In Okla-

homa, for example, it grows twelve feet high, while in Minnesota, where the summer is much shorter, and all the nights are cool, it seldom gets more than eight feet high. But after all, what the farmer wants is well-filled ears, and not a long stalk. So the sooner he can get his corn to turn its attention to making seed, the better.

It is much the same with the other crops. Get them to grow well and strong during the first part of the season, and they will make more and better seeds afterward. The sweet potato sometimes makes such a great top growth that it seems to forget to thicken up its roots, and the farmers say it "runs all to top." When this happens, it is a good plan to twist the stems just above the ground until the juice starts from them. This will remind them of their work, and they will begin making potatoes instead of long stems.

You know, when the tobacco plant is in bud or flower, the entire flower cluster is cut off, so that the food which would go into the seed passes largely into the leaf, making it more perfect. But before the sweet potatoes are twisted, or the tobacco is topped, while the plants are still young, they are hoed often and thoroughly, and made to grow well. When their roots and leaves are well formed, and flowering begins, the hoeing is stopped so as to check stem

growth, for this always results in making more and better seed.

I used to have a teacher who told us that when the plants were in flower anything that checked their growth made them fear that they might die, so they hurried all they could with their work. Do you remember what the plant's business is?

Hoeing makes the plants grow better, by warming the soil, saving the moisture in the soil, letting air into the soil for the roots, and killing the robber weeds.

All the crops that pay better for the extra work of hoeing are called hoed crops. All the work that is done on the soil after the crops are up is some form of hoeing.

XVIII. THE CEREALS

THE small grains — wheat, oats, rye, and barley — are called cereals, and they grow so much alike that we can treat them in the same way. In the Southern and Eastern states wheat is planted in the fall, and the crop is harvested the following summer, but in the north-west all the seed is sown in the spring, and the harvest is in August.

The cultivation of the cereals is best done before the seed is sown. That may seem strange to you, but let us think about it a minute.

Wheat and oats cover the ground so closely, even when sown with a press drill, that if we used a cultivator in the wheatfield, we would tear up at least two thirds of the plants, and that would never do. In Germany they sometimes sow wheat in drills wide enough apart to allow hoeing by hand, but the work is done by old women who get very little pay. If we were to sow wheat in wide drills, there would be danger of its being blown down by the wind. If it grew well, each plant would yield more grain than under our present method, but the whole field would give little, if any, more, and the cost of cultivation would be much greater.

As we grow them, the cereals come up so thick that they smother out a good many weeds, but the

farmer must try to get all the weeds killed before he sows the grain. If plowing is done early, a great many weeds will sprout soon after the land is plowed; and if the land can be harrowed twice before the seed is drilled in, a host of weeds will be killed.

The cereals like a firm seed bed. If the land is dry when plowed, it will need disking and rolling and harrowing to make it fine and firm for the seed. If the land has been in corn or an ensilage crop, which has been given clean cultivation, the farmer sometimes disks the field without plowing and then drills in the seed. In this way he gets a firm seed bed, and if the land is rich and clean this is a good plan. One advantage of sowing small grain on corn land is that the cultivation necessary to make a good corn crop has killed the weeds, so that much of the work for the grain crop is done while the corn is growing.

All the old picture books show us a picture of the farmer with a sack of seed slung from his shoulder, walking across a plowed field, sowing the seed by hand. But a much better way is to plant with a press drill, which sows the seed in regular rows and presses the soil firmly upon it, so that it will sprout quickly and from the first make a good growth. Broadcast sowing must be covered with a harrow, which neither covers the seed evenly nor firmly

presses the soil upon it. The drill is made so that fertilizers can be sown with the grain. Grass or clover can also be sown, and the machine measures exactly the amount of seed that is sown per acre.

Often the small grain is harrowed and rolled after it is up, but when the plants have tillered, nothing more can be done for them; the last harrowing is the last hoeing they will get. During the winter, the small grains may be grazed lightly without harm, and rye is often sown purposely for winter pasture.

In the spring, especially if frost has raised the plants, a good rolling will help them, and thereafter the field must be left until harvest time.

The farmer can not control the weather, and much of his success with cereals depends upon the moisture content of the soil and the weather. But there are things which he can do that will help to make a good yield. He can run his seed wheat through sieves that will separate the large from the small grains, and use only the large grains for planting. He can soak the seed grain in blue vitriol for a short time, then spread it to dry, before sowing, and thus prevent smut in the crop. He can sow late rather than early, and thus lessen the danger from the Hessian fly. He can enrich the soil, and have it in perfect condition at the time of seeding.

XIX. IN THE MEADOW

THERE was once a grass plant that found itself in the midst of a meadow, and it thought it would like to know all about its neighbors. They were a very quiet company and the grass plant had no help from them. In fact, it seemed as if every plant in that field was doing its very best to crowd the other plants. Our plant was of the Orchard-Grass family, and when it first peeped out from the soil it had plenty of room. True, there were a host of other little grasses there, but they were all so tiny that nobody was crowded.

Orchard-Grass.

They were happy too. Big stems of wheat towered above them, and they liked the cool spring-time. As May passed, the shade of the wheat plants was very pleasant, for some days were too warm for

the grasses. But one day in June a noisy monster swept over the little grasses, carrying with it the forest of wheat. Only the stubble remained, and it made hardly any shade.

Timothy.

But our little grass was strong enough by this time to stand the full sun, and it grew faster than before. When it first came up it showed a single erect stem, that soon bore a straight, narrow leaf. But after a few months, it began to send out little side shoots, and before long the Orchard-Grass found itself rubbing against another grass plant. Then it began to think of its neighbor.

All the other grass plants had been doing the same thing, though most of them did not grow as fast as the Orchard-Grass. The Timothy was a

strong youngster, but the Red-Top was very delicate and had hardly thought of branching when it found itself in the way of the Orchard-Grass. The Tall Meadow Oat-Grass and the Italian Rye-Grass were there, but they did not happen to be near our friend. And a little Fescue that had slipped in without being caught waited breathlessly to see if the others were going to put it out of the field.

Red-Top.

The Orchard-Grass did not stop growing while it was thinking of its neighbors. It was almost the strongest plant in the field, and it pushed a shoot right over the Red-Top, which had to bend its back so long that it became a cripple for the rest of its life. The Timothy on the other side was more stubborn and it pushed its own shoots among those of the Orchard-Grass until they were pretty well mixed up.

The Orchard-Grass was quietly watching the

struggle for room that was going on among several other grasses near by, which became so mixed up that the farmer himself could not tell which was which. Here and there in the field a Red Clover grew. It had a deep, strong root that helped it

Meadow grasses.

greatly, so that it was not afraid of being overrun by any of the grasses.

As week after week passed, the grasses crowded each other more and more, and soon their stems were so laced that hardly a plant was growing free. Of course none of the plants grew as strong as they would have grown with plenty of room — even the

Orchard-Grass sent up finer flower stalks than it would have produced if it could have had all the room it wanted. But the farmer was rather glad when he saw his whole meadow so well covered that not a bit of soil could be seen. He knew very well that snug neighbors meant finer hay, with less wood in the grass stems, and that is just the kind of hay his horses and cattle like the best.

When the grasses were strong enough they all began to shoot up their flower stalks, and the meadow was a beautiful sight, for it was a carpet of many shades of green. And the Orchard-Grass, lifting its stems highest of all, admired the rest almost as much as itself. But its feet were very much crowded. It tried to push its neighbors aside, but they only bent a little and kept on growing. And the whole meadow was at its very best.

Just when all the plants were telling themselves how beautiful they were, a fearful shudder went through them all, for they heard that awful noise that as very young plants they remembered in the wheat. The tall Orchard-Grass looked over its lower neighbors and saw a big, clattering machine, drawn by two beasts which nipped at the highest grasses as they passed. And as the thing moved, all the green stalks went down beneath it, and

(100) Mowing a meadow.

beyond, the field was even cleaner than it was when the wheat was removed. Nearer and nearer came the monster, and soon it was upon them. The Orchard-Grass trembled to its very roots, and then a terrible thing happened — the Orchard-Grass was beheaded by one of the beasts, and the next instant it was cut to the ground by the machine.

Who will tell the story of what became of the grasses after the machine had cut them all?

XX. TWO COUSINS

THERE were two cousins, each having a very good opinion of the way in which she stored her food. The name of one was Purple Turnip, and the other

"Miss Early Cabbage."

was called Early Cabbage. Both belonged to the Brassica family, very worthy people, though not so well-born as the Rose family.

It happened that the two cousins found themselves opposite each other in the school garden, and as the days passed, each spent a great deal of time

"Miss Purple Turnip."

in talking to herself about her way of growing. Purple never so much as looked at Early, and Early saw nothing but the soil and the sky, but

sometimes people talk so much and so loud that everybody hears what is said. That is how I happened to hear the two cousins.

Miss Early was very proud of her big leaves. She spread them out to the sun, taking care to arrange them so that as much as possible of each leaf should be in the full sunshine. For several weeks she insisted on showing her big leaves, and the more the gardener hoed, the more she spread them out, until she touched her neighbors in the row. In about two months, however, she seemed to change her plan. Instead of spreading out her leaves, she kept them hidden away in a bud. While the leaves were big, one could hardly see the little bud in the midst of them, but when the great leaves stopped growing, the little bud became larger and larger until it stopped looking like a bud and looked more and more like a cabbage head.

Miss Purple could not boast of big leaves like Miss Early, and, indeed, she was a much more modest person. She did nothing to attract attention. At first she spread her leaves flat on the ground, and later she lifted them larger and stronger, so that the sunshine could touch them on both sides. When her leaves were full grown, she did not change her manner of life, so far as I could see. She did not get a big head, like her cousin, Miss

Early Cabbage. And neither did she send up a flower stalk, as did another cousin of hers, Miss White Mustard. She seemed to be resting. I began to think she was getting lazy, when the gardener came and pulled her neighbor up, and then I saw that she had been making a big round root under the ground, while her cousin was making a head. All the while, each cousin had been telling herself how much better her way of growing was than any other.

I wanted to see what Miss Purple Turnip would do with her round root and what Miss Early Cabbage would do with her big head, so I watched them through the summer. Miss Early's head grew so big that it could grow no bigger, then it seemed to rest awhile, and then one morning — it cracked!

And Miss Purple simply sat there, and did not change at all for several weeks.

In a week or two after the cracking of Miss Early's head, I was surprised to see that she had begun to grow again, and it seemed to me that her growth was even faster than when her big leaves were forming. Out of her head came a tall stalk, that branched freely, and soon was covered with buds, and directly Miss Early was wearing a flowered gown!

And Miss Purple, after her rest, also pushed up a

flower stalk, and when she put on her flowered gown, it was so much like her cousin's that you might have thought they were cut from the same piece of cloth, except that one was a dull pink and the other a yellow.

And after they had admired themselves awhile, and had a good many visitors, they laid aside their flowered frocks, and in a few days the seed pods came where the flowers had been; and soon the seed was ripe.

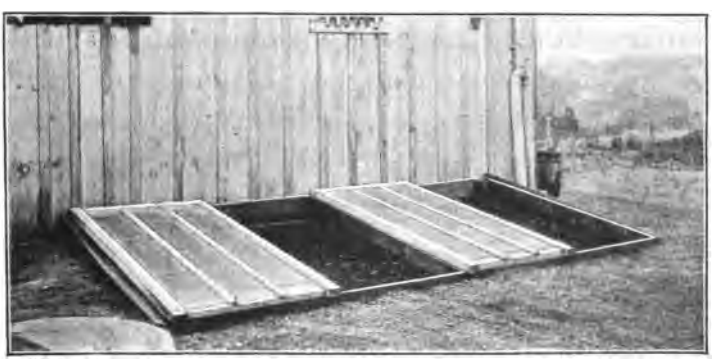
But by the time the cousins were covered with seed pods a great change had come to head and root. In fact, Miss Early Cabbage's head had entirely disappeared, and the round root of Miss Purple Turnip was almost hollow. When I cut Miss Cabbage down, I saw that her stem was hollow too. Now, you all know how good to eat the "heart" of a cabbage head is!

What had become of Miss Cabbage's head, and where had the good part of Miss Turnip's round root gone?

XXI. A BLANKET GARDEN

YES, a tiny little garden, no bigger than a blanket, and you would hardly believe how many things grew in it, nor how much better they tasted than the things that came from the big garden, where plowing and hoeing and all manner of hard work were necessary!

You must know that our blanket garden was more



A hotbed.

like a playhouse than a place for hard work. We made it in January and ate radishes from it in February, and about the time for sowing beet seed in the big garden we were eating lettuce that grew in the blanket garden. The market gardener would have called it a hotbed, but to me it was more like a blanket garden, where the plants were kept cozy

and warm, as we are in the cold winter nights by nice wool blankets. .

In the first place, we dug an oblong space six feet wide, twelve feet long, and eighteen inches deep. It was on the south side of a big barn, where cold winds could not reach it, and where it was warm in the sun, even on cold days. Then we made a wall of posts and boards, fitting close to the sides of our garden. The back wall, toward the barn, was three feet high, eighteen inches above the surface of the ground; and the front wall was thirty inches high, twelve inches above the surface. A piece of two by four joist was set in from back to front every three feet, and the ends of the frame were beveled so as to make an even slant from the back to the front.

During the winter, manure from the horse stalls had been saved, and turned several times, so that when the frame was made, enough hot manure had been saved to fill it. The manure was turned frequently to keep it from burning, and to save the heat, so that it would last until spring in the garden frame. Each time it was turned, it was shaken apart, so as to let in plenty of air. The bedding was left mixed with the manure.

When the frame was ready, a layer of manure nine inches deep was put in the bottom, and tramped,

then another layer was added, and so on until it was eighteen or twenty inches deep, tramped firmly. Then four inches of rich garden loam, containing enough sand to make it drain well, was spread evenly over the manure, and we put the blanket on.

And what do you think the blanket was made of? Not wool, but glass. We had the lumber dealer order us four hotbed sash, each three by six feet, with three rows of glass, the panes ten by twelve inches; the sash rested close on the joists we had put from front to rear of our frame, and so our blanket garden was finished.

In a few days, the manure in the frame began heating, and for a day or two the soil next it was very warm to the touch; but this high heat was soon gone, and then the garden was ready for planting.

We had grown some Boston Market lettuce plants in a box in the kitchen window, and they were about two inches high when the garden was ready. These we planted first, setting them six inches apart in rows nine inches apart. Half way between the lettuce rows we planted Twenty-Day Forcing radish, putting the seed one inch apart and half an inch deep. We planted two sashes of lettuce, but only one sash of radish. Between the lettuce plants under the other sash we sowed

Crosby's Egyptian beet. We sowed four rows of Early Jersey Wakefield cabbage, two rows of White Plume celery, and two rows of Earliana tomato. These seed were sown quite thick in the rows, four inches apart. One sash was left vacant, and when the tomato and celery plants showed their fourth leaf they were transplanted two inches apart so as to have a big start by the time warm weather should come.

The heat from the manure warmed the soil like the May sun, and the glass kept the heat in the frame. We watered the soil with a sprinkler, and on every bright day we raised the sash to admit fresh air, and so the little seedlings found themselves even better off than they would have been in the open ground in spring.

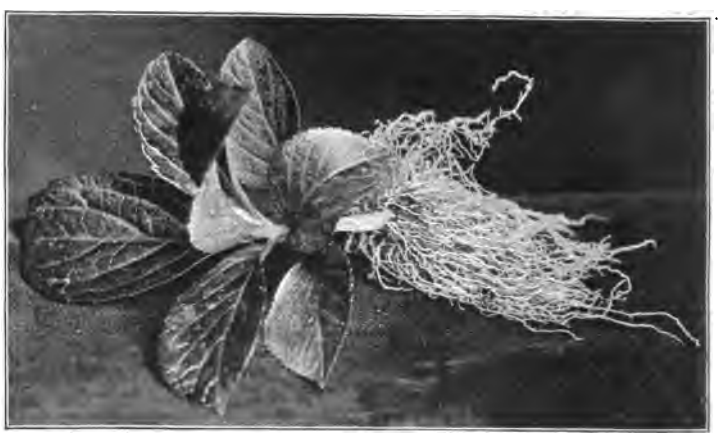
And they needed more attention than a spring garden, but you see the whole blanket garden was so small that it was like play to weed it and water it and air it, and it was very interesting to see the plants grow. Almost before the lettuce plants began to thrive the radishes were ready for use. The radish is a cousin of Miss Turnip and has the same habit of storing food in its root, to use later in seed making.

By the time the radishes were used, the lettuce plants had grown so as almost to touch, and in March they

had formed heads, the inner leaves of which were cream-colored, and so good! When the lettuce was cut, its place was given to flower seeds, and when the flowering plants were sent into the garden, sweet potatoes were set in the blanket garden and their sprouts were ready for planting in June, to make a late crop. So we had radishes and lettuce from the frames before spring came, then we got an early start for our flowers, and finally grew sweet potato plants. Of course the cabbage and celery and tomato plants were planted out when the weather was warm enough, so our blanket garden was a great help, and paid better for the amount of space given it than anything else on the farm.

XXII. CUTTINGS

It has been quite a while since we had our lesson on seeds and buds, and almost all of the crops we have talked about since are grown from seeds. To-day we shall talk about stem buds and how to grow plants from them. The potato, grape, rose, blackberry, geranium, and many other plants are com-



A rooted cutting of hydrangea.

monly grown from cuttings of wood or root that have one or more buds. Perhaps you have thought that only hard plants, like trees, have wood in their stems; but the little threads that run through the leaves of plantain and through corn stalks are all wood, and every geranium stem has a ring of wood

around its pith. Some time when you have them handy I want you to compare the stem of a geranium plant with a long shoot from a peach tree, looking carefully at each from the tip to the base of the stem.

All along the stems I have spoken of there are buds; and if we were only skillful enough and could give it just the right amount of heat and moisture we could grow a plant from every well-grown bud that forms. You may remember that there is a bud in every seed. It feeds on a supply of food stored in the seed until leaves and roots are formed. There is a similar store of food in all stems, enough for each bud that sprouts until it grows leaves and can digest its own food. This is why all other plants that live more than one season are able to push forth leaves in the spring. The buds are nourished on food stored in the stem the summer before.

If a stem, bearing a few buds, is cut from a grapevine in winter, and is planted at once in fresh soil or sand, growth will begin at the approach of summer. The buds will swell exactly as if the cuttings had not been removed from the parent plant. Soon buds will sprout, and while little leaves will form on the new growth, little roots are forming in the soil. By fall the young vine will be three feet long or more, and ready for planting in the vineyard.

In the same way, many flowering shrubs can be grown. Such flowering plants as geranium, carnation, heliotrope, the begonias, and fuchsias are grown from cuttings of new wood. Very soft, rapid-growing shoots are not so good for cuttings as firmer shoots, but hard wood should not be used.

A root cutting of horse radish.

The best way to make cuttings is to cut the base just below a bud, and have at least one joint, making the top cut half an inch above a bud. The cutting should be from one to two inches long, and the end of the shoot makes the best cutting, if it is not too short. Not more than two full-grown leaves should be left on the cutting. If the leaves are very large, the outer half of each can be cut away. This is often done with coleus plants. Plant them in a box of sand, placing them one inch apart in rows two inches apart, setting them not more than one inch deep.

Some cuttings root in ten days, and others require several weeks. The kinds named above take from

two to four weeks to root, depending on the heat. The cuttings can be taken from the sand without injury, provided it is moist. When they are rooted, they are planted in a rich, sandy soil, in pots, cans, or boxes; or if left in the sand until strong roots are formed they can be planted at once in the garden.

Some plants, like blackberry and horse radish, grow readily from root cuttings, the young shoots pushing up exactly as though seed had been planted. The Irish potato tuber is a short, thickened stem that grows underground. Its eyes are buds, and it is these which form the new plants when we grow potatoes. The sweet potato plants are shoots from the roots which are bedded down in the spring. How do we grow strawberries, black raspberries, and red raspberries?

XXIII. TRANSPLANTING

If ever you visit a greenhouse, you will see a great many plants in very small pots, and even the largest plants will be growing in much less space than they would have occupied in open ground.

Chrysanthemums as transplanted.

The florist moves his plants from pot to pot, each time giving the flower a pot only one size larger than it had before. It would be much simpler and a great saving of work to set the cutting, as soon as it had rooted, into a big pot, where it could grow a long time before it would need more room.

But the most interesting place is the evergreen nursery. You know they have nurseries for trees as well as for children. The little evergreens — pine, spruce, hemlock, cedar — are so delicate when they

first come through the ground that they must be grown in a house made of lath screens to protect them from the hot sunshine. A hemlock tree does not grow an inch high the first season. The seeds are sown very thick and when the tiny trees are two or three years old they are taken up and set about two inches apart in rows six or eight inches apart.

A hillside orchard.

Here they spend two more years in the screen house, and then they are transplanted to the nursery rows. Usually the more delicate evergreens will have been moved four or five times before they are ready for sale.

In the Southern States the market gardener sows his early cabbage seed very thick in seed beds in

September, and in early November he transplants them a few inches apart in cold frames, where they are kept until late February or March, when they are set in the garden. If we want very early tomatoes we sow the seed in shallow boxes in January, then set each seedling in a small pot. As soon as roots show against the side of the pot, we set the plant in a larger one, and possibly transplant it a third time before the weather is settled enough to set it in the open ground. I have known tomatoes grown in four-inch pots to have small fruit on them when put in the garden, early in May.

Fruit trees are grown very close together in rows the first year or two. The nurseryman may grow 250,000 trees on an acre, where the orchardist could not grow 250, because when large they would be too close together.

The florist transplants his potted plants to get the greatest growth of root in the smallest space, as his room is always limited; and besides, plants bloom more freely when their root growth is restricted.

The evergreen grower transplants his little trees frequently in order to get as many fine roots as possible near the base of the stem, so that when the tree is sold it will lose few roots in the last digging.

The market gardener transplants his cabbage and tomatoes to prolong his season, growing them in

the winter under glass and getting well-rooted plants for setting in the field.

The nurseryman transplants his fruit trees because he can grow many in a small space, and with little labor, while young; and when they get larger the trees must have a great deal of room.

Transplanting is always a great advantage to the plant when carefully done, for every time a young root is cut several branches will form, in the same way as pruning the limb of a tree causes it to branch more freely. By this means the root-surface is increased, and the plant can thereby secure more food from the soil.

XXIV. ROB'S GARDEN

I WONDER how many boys who read this story dislike the garden as much as Rob did! And I wonder whether boys and girls who have gardens of their own learn at last to love them as Rob loved his.

Spading with narrow forkfuls.

Rob was a town boy who lived with his grandmother. There was a small yard with a little grass plot in front and a garden behind the house. Nothing in all Rob's experience was so annoying as the little garden in the back yard. Whenever he wanted to play marbles in the spring the garden had to be

dug. When all the boys were going swimming in summer the garden had to be weeded. And Rob was fast growing to dislike, not only the garden, but all kinds of plants.

One spring Rob's uncle came home for a visit just as the frost was gone from the garden. He

Fining the soil with a rake.

liked to dig and he had many things to tell Rob about the soil and manures and different kinds of seeds. They worked in the garden together, and for the first time in his life Rob found himself almost enjoying the garden work. Uncle Bert spread a thick coat of manure on the land and turned the soil with deep,

narrow forkfuls, so that when he had finished digging there was no need of hoeing at all, and he made raking so easy that to smooth the surface was almost like play. They saved all the "fish worms" as they dug, for Uncle Bert had a habit of always finding time for a little fun after the work was over.

Smoothing the soil with a rake.

Do you remember what the earthworms do for the soil?

It was a little garden, so small that a horse and cultivator could hardly have turned around in it; so all the work was done by hand. Rob often said before he learned to like the garden that if he could

plow the land, as they did at Uncle Walter's on the farm, it would be all right. But I doubt if farm boys like to plow much better than Rob liked to dig with a spading fork.

Uncle Bert showed Rob how much easier and better a spading fork worked when narrow instead of wide forkfuls were taken; and he showed him how to break and fine the soil by digging the rake teeth into it, and how to smooth the surface by holding the rake handle almost straight up and passing the back of the teeth lightly over it. Then they made straight rows with the back of the rake, and they planted such things as lettuce, radish, spinach, carrot, parsnip, and salsify, in rows fifteen inches apart, covering the seed from one half to one inch deep and pressing the soil over the seed by tapping it with the back of the rake. They set early cabbage plants fifteen inches apart in rows two feet apart. That was gardening enough for one day. Later on beans and tomatoes, sweet corn and cucumbers, found a place in the little garden. You see there were only four people in the family, and while the garden was only 36 by 44 feet in size, it produced plenty of these vegetables for the family.

Now, Uncle Bert had a way of looking at things that was new to Rob, and it helped make the garden pleasanter. When Rob learned that the right way

to kill weeds with a hoe is to scalp them, he looked on every weed as a wild Indian, and went on the war path after them. He stopped cutting deep into the soil as though he were trying to dig it all up again, but he filed his hoe sharp and then cut the weeds off just a little below the surface, stirring them about so that they would dry quickly.

A scalped weed.

Uncle Bert also showed Rob how hoeing, when done in the right way, was as helpful in saving moisture in the garden as harrowing was in the field. While they worked, Rob learned that the weeds were robbers, and that a dry crust among the plants in the garden is a robber also, since it lets the moisture out of the soil into the air. One set of robbers they killed by scalping, and the others they destroyed entirely with their hoes.

Then they went swimming.

Somehow, as the season advanced, it was noticed that Rob stopped scolding, and began to talk of "my

peas" and "my tomatoes." He was taking a pride in his garden. Perhaps the peas and tomatoes had been suggesting things to the boy while they all worked together in the garden. Of course the plants could not dig, nor rake, nor hoe; but they had their own work to do, and they were able to do it well because the boy had learned how to help them.

I wish every boy in this school would try to see how many pleasant ways of doing pleasant things can be found in a garden; and perhaps there is a "swimming hole" near enough to wash away the memory of all the unpleasant parts.

XXV. THE ORCHARD

THERE may be some people who do not like the garden, but everybody likes the orchard. Of course there are different kinds of orchards, but the kind I mean is a place where fruit grows; that is the only kind people like. I know of orchards where sassafras grows among starving apple trees that are full of dead limbs, and bear a great many lichens, and insect pests, and fungi — everything, one might almost say, but fruit! I can't understand why the owners do not cut the old trees up for firewood, and plant the land to crops they like well enough to take care of. Can you?

Before the farmer plants an orchard, he ought to say to himself: "I want to grow fruit on this land, just as I want to grow corn and wheat in the fields. I know I can not get a crop of corn or wheat without doing the work those crops need; so I will do my best also for my orchard, and give it just the care it requires."

It only takes one year to grow a crop of wheat, and the following year some other crop is put in that field. But the orchard must grow several years before it begins to bear, and then, year after year, it ought to yield better and larger crops. If it is not worth caring for, it is not worth having. Give

it just as much care as any other field every year and it will be very apt to give you a good profit. Neglect it and it will pay no better than any other neglected field. That is what I want you to remember while you are planting an orchard.

Choose a hilltop or hillside — a north or west

A fruiting quince tree.

slope is best for almost all kinds of fruit trees. Buy strong one-year-old peach and apple, and two-year-old cherry, plum, pear, and quince. Set apple trees twenty-eight feet apart and all others sixteen feet apart. An orchard looks best and is most easily cared for when the rows are perfectly straight, but if

it is to be planted on a steep slope it is best to set the trees in straight rows up and down the hill, with each row on the same level around the hill. This will give an irregular stand, but it will enable the owner to plow around the hills instead of over them, and in a measure prevent washing.

A cherry tree in full bloom.

Make large holes, cut away all bruised roots with a sharp knife, give them their natural spread and fill in fine soil carefully and firmly around them. The trees should stand about an inch deeper than they stood in the nursery. Every winter the fruit trees should be pruned, and all through the growing season they should be cultivated and protected from insects and disease.

Pruning is cutting out branches in order that those remaining may have more room, more food, and more light, and thus grow better. Wild trees prune themselves. If you will take a walk in the

woods where the trees grow very thick, you may be able to see how they get rid of useless branches.

Fruit trees, however, are planted so far apart that they do not prune themselves readily; and besides, they can not do the work themselves as well as we can.

A well-pruned young apple tree.

Early in the spring, the orchard should be plowed at least six inches deep, and then the disk harrow or the spike-tooth harrow should keep the weeds down until May, when cowpeas can be sown. In August, as soon as the pea hay is made, the orchard is disked, and at once sown to rye, which tillers well before freezing weather, and makes the best kind of soil cover for the winter. Rabbits are apt to gnaw the bark of fruit trees, but they like rye better than bark, and seldom harm trees where rye is growing.

While the trees are young, small-growing corn,

potatoes, strawberries, navy beans, and other crops that require hoeing, but do not rob the trees of too much food, may be grown in the orchard, but after they begin to bear, the trees should have all the soil. No soil is rich enough to produce many crops of fruit without manure, any more than a field could yield large crops of grain year after year without fertilizers.

Many kinds of insects feed on the leaves and bark and fruit of orchard trees, and there are plant diseases, such as mildew, apple scab, and peach rot, that infest them. All these must be guarded against, and with plowing and cultivating and pruning and spraying, the owner of an orchard is as busy as the owner of a wheat farm or a stock farm; and yet there are a great many farmers who think that fruit trees grow like forest trees, and require no care. If we wished to grow peach wood and apple wood, we might treat the trees as we would ash or maple, but we want to grow fruit, with just enough wood for the fruit to hang on.

XXVI. THE GRATEFUL PLANTS

A good many years ago there was a little boy who looked just like me. He never lived in the country, but from the time he was big enough to pick strawberries (and you know a very little boy can do that) he worked during the long summer vacation in a market garden.

There was a wise old English gardener who looked after the boys, and worked with them. He not only showed them how to do their work, but also tried to give them reasons for his methods. And always he would finish his little talks with the same speech: "Boys, you will never make good gardeners until you learn to love plants."

And now, at the close of this little book, I feel like saying to all the boys and girls who have been working with me, "The one thing above all others that I hope you have learned is to love the plants." If you love them well enough, you will study them until you learn their ways, so that you may do everything necessary to make them as perfect as they can be grown. You will study the soil in which they grow, and learn how to make it more fertile, so that it will produce better crops. You will find what kind of grasses will grow best on your farm, and what variety of corn will give the largest

yield. You will see how your neighbor treats his land, and try to make your own as good or better. You will study the weeds and learn lessons in the forest and by the roadside. And once in a while, perhaps, some plant will tell you a secret of its own that nobody else knows.

Sometimes when I am hoeing in the garden, I have a little make-believe conversation with the vegetables. One must be very intimate with the plants before such talks are possible.

One day a tomato plant became very confiding, and it said to me, "I often wonder, when I remember what my great-great-great-grandmother was like, whether men think as much of us tomatoes as we think of men! Every one of us is deeply grateful to man for helping us to improve so rapidly, and to be of so much more importance among the garden plants than our forefathers. I am not ashamed of my family, but when I think how long man loved my cousin, the potato, before he even knew us, it really makes me feel hurt. Of course, *now* everybody loves us, but, can you believe it? there were years and years when people actually thought we were poisonous, and they only allowed us a place in the garden as curiosities. They called us 'love-apples'—your own grandmother will tell you so—but they did not love us." And the tomato sighed at the humble

place its forefathers had held in the opinion of mankind. Then it continued its story: "I must admit that our family has changed greatly since the days when we were called love-apples. Why, I don't believe I look any more like a love-apple than you resemble a wild Indian!"

"How did you change your appearance so much?" I asked. "When I was a little boy, all the tomatoes were either pear-shaped and small, or very much ribbed, and you are as smooth and beautiful as can be."

A ribbed tomato.

"Thank you," said the tomato, "it is so nice to hear pleasant things. I will tell you. One day a man discovered that we were not poisonous at all, but were really very good to eat; so he moved us out of the flower border, where we had always been kept, and where we were crowded, and put us in the big garden, where we could spread out our roots and find plenty of food.

"Now you know when any one does you a kindness you try to return it in some way, and all the plants have the same feeling. Having plenty to eat, we stored up more food, and made better fruit. And our good friend, who became very much interested in watching us, chose the very largest and best fruits he could find among us, and saved the seeds from them. And when these seeds were planted and grew to fruiting size, every plant among them did its very best to make its fruit more perfect. And so it was only a few generations till, by the help of the good man who selected the seeds of the very best fruits each year, we managed to hide all our ribs with flesh. Now everybody likes us; and really, when I think of those dear old ribby ancestors of mine, I feel very sorry that men did not learn to love them sooner.

"But I will tell you a secret," continued the tomato plant. "Every kind of plant in the world, and each plant of every kind, must do its very best for itself or it is apt to die out entirely. My! my! when I remember how much man has helped us tomatoes, I pity the poor forest trees, even though they are ever so much larger than we. We are not crowded, and whenever one of those upstart weeds tries to grow among us the gardener cuts his head off; but nobody helps the forest trees. Of course

the old trees must sow millions of seeds, because somehow man does not love them as he does us, and so does not protect and help them, and though millions sprout in the spring they are no sooner born than they begin to fight one another. You see how

Well-rounded tomato.

it is: there is not room nor food enough for all of them, so very soon they struggle with one another for room and food. Always the strongest win and the weakest die. It must be pitiful to see the dying saplings in a pine thicket," said the tomato. "The strong pines take so much room that they soon

overtop the weaker ones, and you know plants can not live without light. So from the first year, as long as the forest lives, the trees must strive against each other and only the best reach a grand old age.

"All plants, both wild and cultivated, have had much the same history as our family, only among the wild plants the changes have been very much slower than among such plants as man has helped. We love mankind. How can we help it when men have done so much for us? I wish," said the tomato, wistfully — "oh! how I wish that *all* men would love us too; for then we would be even more perfect and beautiful and useful than we are now."

SUGGESTIONS TO TEACHERS

In presuming to add to the curriculum a subject new to the schools and to the teachers, I am hopeful that the teacher may find in it a diversion, and a help in maintaining a live interest on the part of many boys and girls who might otherwise be apathetic toward all school work.

At first thought it seems absurd to speak of agriculture as a new subject in rural schools, surrounded as they are by fields and patronized exclusively by farmers. But as teachers we all have found to our sorrow that English is a new subject to the pupil, though no one can recall the time when he was not familiar with it. And so it is with agriculture, although every pupil in the rural schools may know something about farming. I hope my suggestions will lead the teacher to find purely local illustrative material, for the more concrete we make the first lessons on any subject, the greater our chance of success.

My notion of writing these stories (I would call all of them stories, though in only a few is the story form attempted) is that pupils of the fourth to sixth grades might use one or two of them a week instead of a reading lesson, and that for every story some original work would be required of each pupil. Some stories will be best illustrated by asking for reports of farm operations at home, others by the making of simple experiments at school, and still others by excursions of the class to the woods or to the fields.

In any event, let the teacher remember that these are to be simple lessons, and that they do not attempt to cover the vast field of agriculture. Call them nature studies if you like the name better. Make a school garden and illustrate the stories there if you happen to be enough interested in the idea to make it a practical success. It is true the average country school yard is about the last place an intelligent farmer would think of choosing for field or garden operations, and the average school teacher neither

plows nor sows nor reaps, while on all sides are examples to serve his every need; but a successful school garden is an invaluable aid in all kinds of nature work, and wherever conditions are at all favorable the teacher should attempt one.

It would seem that any form of instruction that begins within the present knowledge of the pupil and carries him step by step into the unknown would profit him. And if the reasons of things can be discovered, rather than taught, the discoverer is an interested voyager in that particular sea.

I have tried in each story to throw a little light on the great subject of economic plant production, and the series as a whole should give the pupil a simple notion of the why and the how of field work.

You will need some material that may not be available in your district. Let your state university or agricultural college help you. These institutions can do no better work than the particular form of "university extension" that will bring them into close touch with the common schools. They can send you grape cuttings and flower slips and give an occasional help over the hard places, if you will look ahead and discover your need in time. If you have a school garden, or want one, they will send you a canna or a dahlia or some other plant to put in it, for every university or agricultural college would like to have a small share in every rural school.

But we all know that only a little of the world's interest is in books; and still less of childhood's interest centers there. Nature allures the children and teaches them many things. We who are interested in the rural schools can do no better work for our commonwealth than to aid in making farm life and the things pertaining to it more attractive to the farm boy or girl. There is a certain amount of drudgery inseparable from farm life, but there is vastly more of interest than many tillers of the soil have discovered. Let us begin with the children and try to give them an idea of their relation to the plant world. It will make work more interesting, and life larger and better.

SUGGESTIONS

I. Introduction. — Take the children to a nursery if there is one in the neighborhood, and show them the little fruit trees. As you go to and from school, be on the lookout for plants that increase by runners, underground stems, etc. In all of them, as the new plants become established the old ones die, and thus the plant slowly moves from place to place. Set a strawberry plant in the school garden, in rich soil. Hoe it and water it well. Layer each runner so as to give the greatest amount of room, and as the new runners appear layer them so that they will root quickly. By fall the single plant should have spread over a circle of more than ten feet. As many as 1260 plants have been grown from one in a single season.

II. Soil. — Give each child a piece of soft stone, like shale or sandstone, and some very dry decayed forest leaves. Let him pound these leaves and the stone into dust, mix them with water in a fruit jar (one tenth dust, nine tenths water), shake violently, and let the mixture stand over night. In the morning let him drain off the water carefully and set the jar on the back of the kitchen stove until the contents can be handled. Compare with soil from a garden and from a stony field. Dig in moist earth for angleworms, using sharp spade (watch for the holes the worms make in the soil); break up spadefuls with the hands to see where the holes go. Let the school visit a river or a creek and see how sand bars and washed banks are made. Let the school visit an old field or a hillside and see gullying.

III. Kinds of Soil. — Have each pupil dig a hole in the garden at home, deep enough to show the change in color between the top soil and that below (subsoil). The pupil should spade one side of the hole vertical, and measure with a rule the depth of surface soil (to changed color). Have each pupil bring a small sample of soil from a field at home and let the class decide whether it is a clay, sand, or loam, or some modification of one of these.

Have a pile of clay and another of sand in the yard, and mix gradually, noting the change. Instead of sand use pulverized dry leaves.

Wet samples of clay, sand, loam, and gravel, and determine the order of their drying.

Plant wheat seed in fresh clay, sand, and loam, and see which sprouts quickest and best. Let the plants dry up, and see which lives longest without water.

The teacher will often find no pure clay, nor clean sand, in his vicinity; the clays differ in color and texture, but are alike in their relation to water, which makes them stiff and plastic.

Sand may be washed and baked in an oven. If clay is treated in the same way, a good lesson is found for the children. Remember that so far as agriculture is concerned, the whole interest in soil rests in its relation to the plant; and as the soil food of the plant is only absorbed in water, the child should be made to see that any soil, by whatever name, or of whatever color or texture, that will allow water to drain from it, and still retain enough to make plants grow, is a safe soil to use for farming. A mixture of pure sand and clay in the right proportions for this result is called loam. Almost everywhere the top soil is loam, even though the subsoil is clay or sand. The top soil always contains more or less decayed vegetable matter (humus), which both enriches it and improves its water-holding power.

IV. The Plant and the Soil. — Secure several blotters from an insurance office, or buy blotting paper in a large piece and fold it to a convenient size. On a Monday morning dip the blotters in water, then sow wheat and radish seed between them. Put them in a closed box or drawer to prevent drying, and thereafter keep them damp but not wet. Remove the cover (upper) blotter every day and watch the seeds grow. By the end of the week, if the schoolroom is kept warm, both wheat and radish will have rooted enough to show root hairs. The root tips increase in length, and if they had hairs on them, the hairs would all be rubbed off as the root tip pushed into the soil. Only the tips of

the root lengthen. Carefully dig up young plants of any kind, wash the soil off very gently, and make a study of root hairs. Potted geraniums are very good for this exercise, when the roots have reached the sides of the pot. There are no hairs on old roots, because they have done their work in that part of the soil, and as the root pushes into fresh soil the hairs develop there.

Tree roots are almost all — even in the largest trees — within four feet of the surface, because there is much more plant food in the surface layers of soil than in the lower or subsoil. Surface soil is colored by decayed leaves, twigs, etc., and such vegetable matter is washed into the soil by rain. The upper layers of soil act as a filter, and by the time the water has passed through three or four feet of soil it will have become colorless.

Make all the observations suggested in the story.

V. Little Rivers under the Ground. — Find a cut in a wood road like that described, and watch what happens after a rain.

Underground waterways of this kind are better than surface gullies, because they do not wash the rich surface soil away, and they prevent gullying. After a sharp shower take the class out to a gully and see how much washing is going on. This is an especially important subject for the South, because our soils wash away very badly, and every effort to prevent this waste should be encouraged.

VI. What the Forest does for the Soil. — Have an excursion to a thick woodland, if possible adjacent to orchards, grainfields, and meadows. Study the surface of the soil in all. Why do the leaves not make a mulch (soil cover) in the orchard as they do in the forest? Why does not the meadow grass decay and make humus like the forest litter? Because much of the grass is cut for hay, and what is left decays very slowly, since the sun keeps it dry. Grass really does make humus in time. The prairie soils of the West are very rich in humus, made entirely from decayed grass, leaves, stems, and roots. In the forest see whether all kinds of leaves decay with equal rapidity. Compare

especially needle-shaped leaves (pine) with broad leaves (maple, oak, etc.).

Why do ladies get leaf-mold for their house plants? Study particularly some abandoned field, such as is described in the story. Have the pupils bring reports from home of the length of time the different farm fields have been in cultivation, and of the results of parents' observations of effect of forest growth in reclaiming land.

VII. The Robber Farmer. — The object of this story is to show the importance of fertilizing the soil. The teacher should not attempt to explain the composition of fertilizers and manures, but the pupil should be impressed with the fact that every plant that is removed from the farm takes away a small but definite amount of plant food, and if this is not replaced the fields will gradually become sterile. In fact, good farming demands that each year more plant food (fertilizers) be added to the soil than is removed in the crop, thus gradually improving instead of reducing the soil fertility.

Let each pupil bring the history of one field in the home farm as far back as he can learn it — just what crops were produced in it, and just how much manure or fertilizer was applied; whether it has been under cultivation ever since it was cleared of forest, or whether it has been in grass, and how often and how long each time. Such records will show whether there is any "robbery" going on in your neighborhood.

VIII. Weeds. — Work with weeds can go on from this lesson to the end of the year. Have each pupil make a collection of weeds. Get a specimen in flower and press it in an old book, or make a press of newspapers with a piece of board weighted by a stone. If you cannot name them, your State Experiment Station will doubtless be glad to help you, though every rural teacher should have a Gray's "Manual of Botany," and learn to classify his own specimens. Each specimen in the pupil's collection should be labeled with its common name, and a brief description of its bad habits, with the means of destroying it. If collections

of the ripe fruit and seed can be secured, all the better. Make a weed collection for the school. In this connection teach the class that all the time there is a great struggle going on among the plants for food and for room to grow in. Not one in ten thousand of the seeds that sprout every spring lives to produce seed, and so man must protect the plants that are useful to him by destroying the others, which he calls weeds.

Have each pupil find all the different weeds he can in his father's hayfield, and in the cornfield. In which is there the greater number, and why? What weeds live in the ground over winter? What weeds spread by seed only? What weeds spread by stems? What weeds produce most seed? What weed seeds have wings, or hair, or silk, or any other means of being spread by the wind? Bring specimens to school (always by preference the entire plant). What weeds spread by fastening themselves to animals or to people's clothing? You see there are many things to work up about the weeds. Tillage is stirring the soil. Dust mulch is a soil covering of dust, instead of leaves, straw, etc., commonly used for mulching.

IX. What the Russian Thistle Did. — The Russian thistle (*Salsola kali*) is a tumbleweed — one of a class which breaks off at the ground when its seed is ripe, and is blown before the wind for a great distance, dropping its seed as it goes. This form is less common in the east than in the plains, and is given as showing one of the many interesting ways the plants have of spreading their seed abroad. A valuable exercise is the study of seed distribution by different kinds of plants.

X. The Plant's Business. — Have the class tell the special usefulness to man of many plants not named in the lesson, and just what part of each is used.

Flax. — Woody part of stem for linen. Seed for "linseed" oil and oil cake.

Corn. — Pith to make cellulose, with which the sides of battleships are stuffed, so that when a ball pierces the outer wall the cellulose swells quickly and fills the hole.

Hemp. — Woody part of stem for ropes.
Hops. — Fruit for bread or beer making.
Tobacco. — Leaves for smoking, etc.
Peanuts. — Fruit for food.
Artichoke. — Root for stock food.
Globe artichoke. — Buds, vegetable, for food.
Asparagus. — Young shoots, vegetable, for food.
Rhubarb. — Leaf stalk, vegetable, for food.
Cauliflower. — Flower bud, vegetable, for food.

Use especially all farm and garden plants known in your neighborhood.

XI. Buds and Seeds. — Have a boy dig up a number of blackberry and red raspberry roots and have the class find buds on them (not roots really, but underground stems).

Find buds on Bermuda, Johnson, or other grass and on corn. Tear away the sheath of the leaf which surrounds the stem of grasses and grains, and at its base, attached just above the joint, you will find a little bud. Compare this, as to position, with the tree buds. Compare the potato tuber (the potato itself) with the potato leaf stem. Find buds on both, and see if there is anything on the potato that compares with the leaf.

The bright colors of flowers are undoubtedly there to attract insects. Dr. Mueller has written a large book, devoted entirely to lists of insects that visit the different flowers. Have pupils watch a flower on a bright morning and see how many kinds of insects get into it.

Green-colored flowers are wind-fertilized — the Carolina poplar, walnut, oak, ash, and most other forest trees, are of this class. Many plants, like the red clover and orchids, could not bear seeds at all if the insects did not help them.

Soak beans in water twenty-four to forty-eight hours, then slip off the skin, separate the seed-leaves, and see the bud between them. Compare with corn treated in the same way, and with buds on growing plants.

In the spring watch the growth of leaf buds on a tree and compare with the sprouting of seed — strikingly similar.

XII. Why do we Plow? — Good plowing is seldom seen, and the pupils of grades four to six often have this work to do. One of the best things we could accomplish for agriculture would be the improvement of plowing. Why not have a plowing contest some day, and ask three of the best farmers in the neighborhood to serve as judges? Let the prize be a blue ribbon, and let it be understood that to do work well is in itself the greatest prize. Have the pupils measure (with a rule) the depth of the plowing that is done at home. Have them report on subsoiling. Tell the boys to take a spade and dig straight down in a grainfield, a cornfield, and a meadow, shaving one side of the hole until smooth, and see if they can tell from the appearance of the soil how deep it has been plowed. Good plowing means straight furrows, so narrow that all the land is turned, and the burying of all stubble, weeds, or other surface covering. The deeper the plowing, the greater the benefit to the soil, provided no more subsoil is turned up than will weather (crumble) in a single season.

XIII. Give the Crops Plenty to Eat. — The elements which all plants require for growth are carbon, hydrogen, oxygen, nitrogen, potassium, iron, sulphur, phosphorus, magnesium, sodium, chlorine, calcium, and silicon. Carbon is taken in through the pores of leaves. Water is composed of hydrogen and oxygen, and this is absorbed from the soil by the roots. All the other elements named are dissolved in the soil water in the form of nitrates, sulphates, phosphates, etc.

If you have a school garden, good work can be done by growing the same crop in beds that have not been fertilized and beds fertilized with manure, cottonseed meal, acid phosphate, muriate of potash. Beds ten by ten feet will not require more than one pound of meal and of phosphate and a quarter of a pound of muriate of potash. Plant one bed to which the last three fertilizers have been added — two and one quarter pounds of mixed

fertilizer. If you can get nitrate of soda, plant one bed without the meal fertilizer, and after the plants are up sprinkle one eighth of a pound of fine nitrate next to the plants. In three or four weeks repeat the nitrate.

If you have no school garden, get the nearest neighbor to the school to let your class do this work in his garden. Corn, small grain, or any garden vegetable will answer the purpose.

Have the pupils report what fertilizers, and quantity per acre, are used on the different crops at home.

Watch the effect of drought on different crops; of too much wet weather. Ensilage is a crop that has been chopped fine and packed while green in an air-tight place, called a silo. Ensilage is an especially good food for dairy cattle.

XIV. Sowing the Seed. — Let each pupil mark a bean plant at home, and save it until all the beans are ripe, or yellow; then count the number of pods and the number of beans. The bean makes comparatively few seeds. A fifteen-year-old apple tree should bear fifteen bushels of apples. If there are one hundred and fifty apples in a bushel, and they average seven seeds each, how many seeds would a ten-acre orchard contain if the trees stood twenty-eight by twenty-eight feet? Tell the class the parable of the sower (Matt. xiii. 3–8).

From a handful of wheat select a hundred of the largest, plumpest grains and plant in a row (at home or in the school garden). In a row beside the first plant a hundred of the smallest, shriveled grains. Any other seeds will do equally well — radish are especially good, because they mature quickly.

Plant one lot (using the same number of seeds in all lots) without firming the soil above them. Firm the soil on the second lot. The result is most marked in dry weather.

Plant one lot in rough, lumpy soil, another in well-fined soil (particularly useful, as many farmers neglect preparation of soil for seed).

A blotting-paper garden is especially useful for showing effects of moisture. Submerge one blotter of seeds in water, keep a

second dry, a third wet, but with access to air, and a fourth damp but not wet. Comparisons are interesting. Have each pupil examine daily at the same hour and keep a written record of the number of seeds that sprout each day.

A cover crop is anything that is grown to prevent soil washing, such as rye, crimson clover, etc. The cover crops are usually sown in early fall, and are plowed under in the spring, thus becoming important means of soil improvement.

XV. Round and Round the Farm. — Rotation of crops is a part of good farm management. If there is a farm in your neighborhood where it has been in practice for several years, make an excursion to it, and go over the fields with the farmer, getting him to explain his system to the children. If you have any old and young forest growths near your school, see if the new growth is like the old forest near it. The forest is very apt to "rotate." Find out what crops are most commonly grown in your neighborhood and get the help of your best farmer in arranging a rotation, making a diagram to suit the locality. All the fields need not be of the same size or shape. Have each pupil make a map of his home farm, and plan a rotation for it, based on the experience of the best farmer in the neighborhood.

XVI. Stirring the Soil. — Make experiments in the school garden, or home garden, in mulching a little square (say, three hills square, nine hills) of corn one foot deep with grass, straw, weeds, or any other litter. Keep the surface of the ground on a similar square adjacent, hoed one to two inches deep, so that no crust is allowed to form on it. On a third square scalp the weeds, but do not hoe nor cultivate, keeping clean of weeds. Note the results from week to week. Measure the height in inches to the top of the stalk (including only the sheath of the youngest leaf — not to its point). Note the yield.

If any of your neighbors use fine-shovel (spike-toothed or two-inch) and others use "bull-tongue" or double-shovel cultivators, compare the work done, and show which is best, and why.

Study for yourself, in the practice of your neighbors, the methods of cultivation employed, keeping in mind the character of season (wet or dry) and of the soil.

XVII. Hoed Crops. — If there is a market garden or "truck farm" in your neighborhood, make an excursion to it, and see how much more thoroughly crops are tilled than on the average farm, especially the hoed crops. Examine market gardeners' tools and implements and show how well adapted they are to the stirring of the soil.

In the school or home garden try the experiment, in rows of beans side by side, of keeping one well hoed and another hoed very little. Early cabbage is a specially good crop for this exercise. Take ten plants for each treatment. Stir the soil well every week around the first ten and scalp the weeds only about the second.

Try the effect of late cultivation (hoeing) on sweet corn. Keep hoeing one lot until it is ready for market; stop a second as soon as the first tassel shows.

XVIII. Cereals. — Impress the fact that planting small grain in weedy land is throwing away a part of the crop, because every weed takes food that ought to go to the grain, and there is no practical way of killing the weeds after the grain is sown.

Get each pupil to report the exact way his father treats his grainfield. When is it plowed? How deep? How often is it harrowed before planting? How much seed is sown per acre? How much and what fertilizer is used? What kind of a seeder is used? Is it rolled after seeding and in spring? At what stage is it cut? How is it harvested (stacked, or threshed from field)? You will be surprised how good a story your boys and girls can tell of the wheat or other small grain. "Tiller" means to branch at the surface of the ground.

XIX. In the Meadow. — Meadows and pastures are fields in which grass is the crop raised. If the grass is cut for hay, the field in which it grows is called a meadow. If animals are grazed on the grass, the field is called a pasture.

As a rule the farmer cuts hay in the early summer, and when the grass plants have started to grow again he turns his cattle or sheep on the meadow for fall pasturage.

We must remember that the hay crop is made up of single grass plants, the same as wheat, or corn, or cotton. There are a great many more grass plants growing on an acre than corn plants, and in the case of the grass each plant branches at the ground or sends out runners, which so intermingle that it is hard to pick out a single plant from its fellows. So we have come to think of grass as a sod, or meadow, or pasture. Let us not forget, however, that every lawn and meadow and pasture is made up of separate grass plants, each of which after a time will send up flower stalks and will mature seed.

Meadows and pastures are grown for hay and for grazing. In both cases the most useful part of the grass plant is the leaves. If the seed is allowed to ripen before the grass is cut, the hay will be much poorer in quality than if it were cut in the blossom. Cattle will not do so well in grass that has gone to seed, as in grass that is young. The reason is that almost all grass seed are very small and quite hard, and are not digested by the animal that eats them. We know that the seed contains stored food, which was made in the leaves. If the grass is cut just as the buds begin to bloom, most of this stored food will be contained in the stem and leaves, and thus the animals feeding on the hay will get it all.

If the farmer wants to grow grass for hay, he should cut it as the first bloom appears. If he intends to thresh it, like wheat, and sell the seed, he should cut it when the seed is all ripe, but before it begins to fall.

The grass is a very delicate plant when it first sprouts, and the wheat or oats protect it by growing more rapidly. It grows slowly in the shade of the grain, but when the crop is cut, the grass plants are strong enough to be helped by the full sunshine, and by fall the meadow land can be grazed lightly. Meadow land that is fertile and has a good water supply will yield good

hay crops for several years without reseeding. But each year it is apt to get a little weedier, and it is best to put the meadow land in regular rotation. Among the best meadow grasses are timothy, redtop, and orchard grass. Where it can be grown, red clover should always be mixed with the meadow grasses. Meadows should always be plowed under when they become weedy, and the best crop to plant in them, especially if clover has been mixed with the grasses, is corn or potatoes.

Rough land can often be more profitably used for pastures than for cultivation. In mountain regions, if enough trees are left to provide a light shade, blue grass makes a good permanent pasture, especially if cottonseed meal forms a part of the cattle feed, the sod improving with age. Early in the spring the entire pasture should be harrowed to scatter the manure evenly over it. In the South a good permanent pasture can be made of Bermuda grass, which is one of the best soil binders, and is very useful for preventing the washing of hillside lands. It is hard to get rid of, and should be kept out of fields that are in regular rotation.

Have the pupils learn when the meadow at home was sown, and bring to school as many different kinds of weeds as they can find in the meadow; also as many different grasses as they can find. If you have any trouble in naming the grasses, send a sample of leaf and flower or seed stalk to your university or experiment station.

Have each pupil write a description of the way hay is made on his home farm.

XX. Two Cousins. — One of the most important lessons in plant culture is the fact that the plant is a machine for digesting, storing, and using food. In youth the plant is constantly digesting more food than it uses in growth, and this excess is stored up in the stem, the root, or the leaf until the flowering and fruiting comes. Plants bloom only when they have reached a certain maturity, and the rapid development of flower and seed is explained by the great amount of stored food within the plant. In the cases given, the bud (cabbage head) and root (turnip) are storehouses.

You know the peach blooms before there are any leaves on the trees. All the material in the flowers was stored in the twigs the year before. This explains also how all trees start to grow in the spring — on food stored up the summer before. How very necessary, then, to make the soil for crops rich, since well-fed plants produce the heaviest crops.

Children can be greatly interested in this subject, and it is full of lessons. The sprouting of seed depends on the store of food within it. The starting of growth in the spring, fruitage — the whole operation of plant growth — seems to center here.

Have the class report on different parts of plants used as storehouses — Irish potato, sweet potato, cowpea, wheat, corn, artichoke, gladiolus, mullein, burdock, timothy grass, etc. These reports should be made after discovering an enlargement of certain parts, as the tuber of the potato and the root of the mullein weed before its flower stalk forms.

XXI. A Blanket Garden. — It is believed that the directions in the lesson for making a hotbed are explicit. If you have no way of getting money for sash (though almost any school can arrange an entertainment for the raising of necessary funds), try a similar framed garden at school after the principal danger of frost is past in spring. A board covering at night will be sufficient protection. It will succeed better than a big school garden at first because its small size will mean less work, and the entire class can claim a share in it. Watch the watering. Water only when dry, then give a soaking, and as soon as the surface is dry enough hoe it or break the crust. Lift the sash every day to admit air, but guard against frost on cold days. It will stimulate interest in the patrons if you grow enough early tomato (variety Earliana) plants to give each pupil a dozen or two for his home garden.

XXII. Cuttings. — By all means have a box of sand in the school window, if you cannot arrange a hotbed (blanket garden), and have the pupils bring slips of geranium, heliotrope, coleus, or any other plants. Take a box not more than four inches

deep. Place in it three inches of clean, sharp sand, and plant the cuttings as described in the lesson. Keep the sand damp and after ten days or two weeks pull up a cutting of each variety to see if roots are forming — resetting at once. As soon as a root shows one fourth inch long the cutting can be potted in a rich sandy loam. In the schoolroom the pots had best sit in shallow boxes of sand in a sunny window.

Have all the pupils make hard-wood cuttings of grapes and such shrubs as spiræa, golden elder, crape myrtle, and the flowering shrubs generally. These are to be made in the late fall or winter, and will not begin to grow until the following spring. But they grow so well that they are large enough to set in their permanent places when one year old. Make blackberry and horseradish root cuttings.

XXIII. Transplanting. — The value of transplanting is easily illustrated in the case of potted plants. When soft-wood cuttings are rooted, set them first in very small pots. In a month or six weeks the roots will show against the sides of the pots (you can turn the plant out of the pot by inverting the pot and giving it a sharp tap on the edge of the table). Then set the plant in a three-inch pot, packing a very little soil all around the ball of earth with a stick, until the plant is firm. In a few weeks it will need transplanting again. If you will leave a few geraniums in three-inch pots, and transplant others successively into four, five, and six inch pots, those in the three-inch pots will bloom soonest, but the others will grow best.

If you have a school garden, try resetting shrubs or forest trees when one, two, and three years old, and compare the roots with those of trees that have not been reset. This exercise is especially valuable with walnut, hickory, and the oaks grown from seed.

XXIV. Rob's Garden. — In this story I have endeavored to suggest what sympathy means to boys when they have irksome tasks in hand. The story may be applied not only in the garden but with book lessons as well.

One of the best exercises in this course is in connection with this lesson: How large an amount of any garden or field crop can be grown on a small (measured) area of land? Can a boy or a girl grow enough beets, beans, cabbage, corn, or any other vegetable on one square yard of garden land to feed a family one meal? Try it with several vegetables — let us say lettuce, beets, cabbage, tomatoes, and snap beans. That would require a plat of land three by fifteen feet in size. Explain to the class how closely these plants can stand when mature: lettuce and beets three inches apart, in rows twelve inches apart — but the thinnings can be used, so drill close in the rows; beans two to three inches apart, in rows fifteen to eighteen inches apart; early cabbage eighteen inches apart, in rows eighteen inches apart; tomatoes three feet apart. Remind the class that a tomato plant can be set in the center of the early cabbage, and of the lettuce, beets, and beans; so they can have four tomato plants — or they can get two or more crops of lettuce. The problem of how much crops can be grown from a small area can be worked out in many ways, and is an interesting and practical one. From the crop on his five square yards let the pupil estimate how much might be grown on one acre.

XXV. The Orchard. — There are many lessons for boys and girls in the way trees grow and bear fruit. Ask your class which bears the more nuts, a walnut tree in an open field or one closely surrounded by other trees. Why? Which yields the more useful timber, and why? The trees in the open develop a great crown, and of course nuts only grow out on the young branches, so the more branches a tree can have, if they get light enough, the more nuts it can produce. On the other hand, the trunk of a tree is best for timber, because it has few knots and is of large size. When trees grow close, their trunks are long, the lower limbs being shaded out.

In their rivalry for light there is the same competition among the branches of an orchard tree, or any other tree planted in the open, that exists among the close-growing trees of a forest.

Prune out the weakest, or those tending crosswise of other limbs, and you admit light enough for the full development of the remainder.

Study frost localities. The cold air settles in the low places. Often there is a frost at the bottom of the hill and none at the top. This is especially important in choosing a location for peaches. Children can observe frost phenomena as well as adults. When the center of a fruit bud has turned black or brown, it has been killed by frost. Often the peach crop will have been killed even though there is heavy bloom, because the petals of the flowers are hardier than the ovaries.

Above all, impress the idea that fruit is a crop, the same as corn, and an orchard requires tillage the same as a cornfield. That is why crops are planted between the trees — to insure their cultivation, and to get some return from the land while the orchard is too young to bear.

XXVI. The Grateful Plants. — It is the purpose of this story to suggest how farmers may improve their crops by careful selection. In this work not only the seed, but the plant on which it grows, should be observed, and only the best plants should be saved for seed.

If earliness is the most important quality (as in raddish, lettuce, etc.), the first plants to mature should be saved for seed, and only their plumpest seed should be used. Selection can be made for size, flavor, color, or any other quality.

Variability is a law of nature, and hardly any two plants are exactly alike.

Have pupils select the largest ten heads of wheat they can find in a field, the earliest cabbage in their home garden, or the largest flower on their favorite plant, and save the seed for next year's planting. Many practical exercises are possible.

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